AFWAL-TR-80-3115



AERODYNAMIC ANALYSIS OF A FIGHTER AIRCRAFT WITH A HIGHER ORDER PANELING METHOD

A. R. DUSTO

Boeing Military Airplane Company Advanced Airplane Branch P.O. Box 3707 Seattle, Washington 98124



NOVEMBER 1980

TECHNICAL REPORT AFWAL-TR-80-3115
Final Report for Period September 1978 - January 1981

Approved for public release; distribution unlimited

IE FILE COPY

FLIGHT DYNAMIC LABORATORY
AIR FORCE WRIGHT AERONAUTICAL LABORATORIES
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433

81 5 26 061

NOTICE

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture use, or sell any patented invention that may in any way be related thereto.

This report has been reviewed by the Office of Public Affairs (ASD/PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

WILLIAM A. SOTOMAYER

Aerospace Engineer Aeroelastic Group FREDERICK A. PICCHIONI, Lt Col, USAF Chief, Analysis & Optimization Branch

FOR THE COMMANDER

RALPH L. KUSTER, JR., COLONEL, USAF CHIEF, STRUCTURES AND DYNAMICS DIVISION

FLIGHT DYNAMICS LABORATORY

"If your address has changed, if you wish to be removed from our mailing list, or if the addressee is no longer employed by your organization please notify AFWAL/FIBRC, W-PAFB, OH 45433 to help us maintain a current mailing list".

Copies of this report should not be returned unless return is required by security considerations, contractual obligations, or notice on a specific document.

AIR FORCE/56780/24 April 1981 - 160

SECURITY CLASSICICATION OF THIS PAGE (When Date Entered)	627
1. REPORT DOCUMENTATION PAGE 1. REPORT NUMBER 12. GOVT ACCESSION NO.	READ INSTRUCTIONS BEFORE COMPLETING FORM 3. RECIPIENT'S CATALOG NUMBER
A TITLE (and Subtitle) AD-A09940L	S. TYPE OF BEPORT & PERIOD COVERED
Aerodynamica Analysis of a Fighter Aircraft with a Higher Order Paneling Method	Final Report. Sept 1980 Ton 6. PERFORMING ORG: REPORT NUMBER
A. Dusto	8. CONTRACT OR GRANT NUMBER(s).
9. PERFORMING ORGANIZATION NAME AND ADDRESS Boeing Military Airplane Company Advanced Airplane Branch P. 0. Box 3707 Seattle, WA 98124	Program ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Project 2404 Task 10, Work Unit 01
Air Force Flight Dynamics Laboratory (FXM) Wright-Patterson Air Force Base, Ohio 45433	November 1980
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	Unclassified
16. DISTRIBUTION STATEMENT FOI this Report!	15. DECLASSIFICATION/DOWNGRADING SCHEDULE
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, If different from	m Report)
18. SUPPLEMENTARY NOTES	C
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)	
F-5 Airplane Panel Method Helmhotz Equation Potential Flow Higher Order Unsteady Flow Linear Flow Wing	
ABSTRACT (Continue on reverse side it necessary and identity by block number) This report presents results from analyses of steed several configurations involving the wing of the several configurations involving the wing the clean wing a wind tunnel wall bounded atmosphere), the wing wind mounted at the wing tip, and the wing with an extension of the wing wind and several configuration of the wing configuration of the wing with an extension of the wing with an extension of the wing wind of the wing with an extension of the wing with a wing wing with a wing wing with a wi	F-5 fighter airplane. The methods and the configurations (both in an unbounded and in with an external missile store ernal missile store and . The flow Mach number
DD 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE	SSISICATION OF THIS PAGE (III - ID.) - P.
	1597 - HW X

SEC, INITY CLASSIFICATION OF THIS PAGE(When Data Entered)

Jan)

My

flow. Each steady flow case is analyzed at three angles of attack $(0.5^{0}, 0.0^{0}, -0.5^{0})$ while each unsteady flow case consisted of unsteady pitch oscillation about zero angle of attack. The reduced frequency of the oscillation was in the range from 0.2498 to 0.3955. The computed results include chordwise pressure distributions along wing sections at eight spanwise locations from 18.1 to 97.7 per cent semispan. The results also include the coefficients of lift and pitching moment for each complete configuration as well as the coefficients of aerodynamic force and couple arising from the pressure on only the surface of the missile store.

>

SECURITY CLASSIFICATION OF THE PAGE(When Date Ente

FOREWORD

The report was prepared by the Boeing Aerospace Company, Seattle, Washington. The work was sponsored by the Flight Dynamics Laboratory (AFWAL/FIBR) at Wright-Patterson Air Force Base, Ohio. The sponsorship was through contract F33615-77-C-3051 with W. A. Sotomayer as technical monitor.

The report consists of a summary of the aerodyanmic theory used in the steady and unsteady numerical calculations, a presentation of the aerodynamic modeling, and surface pressures and force coefficients.

The principal investigators were Dr. A. Dusto and Dr. M. A. Epton of Boeing. They were assisted by Dr. F. T. Johnson, Dr. E. J. Zeppa, and Dr. P. E. Rubbert of Boeing.

Accession For NTIS GRA&I DTIC TAB Unannounced Justification By Distribution/
DTIC TAB Unannounced Justification By Distribution/
Unannounced Justification By
Justification
By
Distribution/
Distribution/
Availability Codes
An Lundor
hist Epscial
1 0/
$ \mathcal{A} $

TABLE OF CONTENTS

		Page		
1.	Summary	1		
2.	Introduction			
3.	Description of Configuration Evaluated			
4.	Analytical Method	4		
	4.1 Problem Formulation	4		
	4.2 Numerical Method	8		
5.	Panel Method Model	9		
	5.1 Surface Paneling	9		
	5.2 Steady Flow Boundary Conditions	12		
	5.3 Unsteady Flow Boundary Conditions	16		
6.	Computed Results	17		
	6.1 Aerodynamic Surface Pressure Distribution	18		
	6.2 Missile Store Aerodynamics Force Coefficients	19		
7.	Conclusions	22		
Raf	Farancas	23		

LIST OF SYMBOLS

LATIN	
a _O	freestream speed of sound, m/sec
BET	right hand side of general boundary condition
b _R	wing span, m
С	coefficient of mass flux normal component in general boundary
	condition
C ₂	rolling moment coefficient
C _m	pitching moment coefficient
c _p	$\frac{p - p_0}{\frac{1}{2} \rho_0 U_0^2}$ pressure coefficient
c_R	reference chord length, m
c_{γ}	side force coefficient
c_{Z}	lift force coefficient
D	coefficient of velocity potential in general boundary condition
Ď	surface point displacement vector, m
î, ĵ, k	unit base vectors of reference coordinate system
$k = \overline{\omega} C_R/2$	reduced frequency
Mo	Mach number of freestream
n	unit vector normal to a surface
p	pressure, kg/m ²
Po R	freestream pressure, kg/m^2 position vector of an arbitrary point, m
\overline{R}_R	position vector of a reference point, m
S	surface,
S _R Ť	reference surface area, m^2 unit vector in an arbitrary direction, also coefficient of the
	flow velocity in general boundary condition

U _o	freestream velocity, m/sec
Ÿ	disturbance flow velocity, m/sec
W	flow mass flux vector, kg/m sec ³
₩	disturbance flow mass flux vector, kg/m sec ³
x,y,z	coordinates of a point in the reference coordinate system, m
GREEK	
	,
α	angle of attack, radians
α _C	camber angle of incidence, radians
αt	thickness angle of incidence, radians
$\beta \equiv \sqrt{1 - M_0^2}$	compressibility coefficient
$\overrightarrow{\nabla}$	gradient operator, 1/m
ø	disturbance velocity potential, m ² /sec
Φ	total velocity potential, m ² /sec
ρ	fluid mass density, kg/m ² sec ²
ρ _O	freestream mass density, kg/m ² sec ²
$\frac{\mathbf{r}}{\mathbf{r}} = \frac{1}{2} \overrightarrow{\nabla} \times \overrightarrow{\mathbf{D}}$	surface rotation, radians local coordinates
σ	source strength
$\sigma_0, \sigma_r, \sigma_n$	coefficients of Taylor series expansion of σ in local panel

 $\sigma_0, \sigma_\xi, \sigma_\eta$ coefficients of Taylor series expansion of σ in local pane coordinates

u doublet strength

 $μ_0, μ_\xi, μ_η, μ_{\xi\xi}, μ_{\xi\eta}, μ_{\eta\eta}$ coefficients of Taylor series expansion of μ in local panel coordinates

 $\omega \qquad \qquad \text{circular frequency of oscillation, radians/sec} \\ \overline{\omega} \equiv \omega/U_O \qquad \qquad \text{reduced frequency relative to unit of length, 1/m} \\$

```
OPERATORS
```

```
limiting value of ( ) at a point approaching a surface point
( )
               from the lower side
               maximum value of ( )
( )<sub>max</sub>
               limiting value of ( ) at a point approaching a surface point
\left( \right)_{u}
               from the upper side
               x component of ( )
( )<sub>x</sub>
               y component of ( )
( )<sub>y</sub>
               z component of ( )
( )<sub>z</sub>
               complex amplitude of ( )
( )*
\Delta(\ )\equiv (\ )_u-(\ )_{\&} jump in ( ) across a surface
```

SUMMARY OF FIGURES

Conf	iguration	Figures
I.	Clean Wing Panel Geometry	18
	Steady Flow Pressure Distributions	19-210
	Unsteady Flow Pressure Distributions	211-274
II.	Clean Wing + Tunnel Walls Panel Geometry	275
	Steady Flow Pressure Distributions	276-323
	Unsteady Flow Pressure Distributions	324-353
III.	Clean Wing + Tip Launcher Panel Geometry	. 356
	Steady Flow Pressure Distributions	357-380
	Unsteady Flow Pressure Distributions	381-396
IV.	Clean Wing + Tip Launcher + Missile Body Panel Geometry	397
	Steady Flow Pressure Distributions	398-421
	Unsteady Flow Pressure Distributions	422-437
٧.	Clean Wing + Tip Launcher + Missile Body + Aft Fins Panel Geometry	438
	Steady Flow Pressure Distributions	439-462
	Unsteady Flow Pressure Distributions	463-478
VI.	Clean Wing + Tip Store Panel Geometry	479
	Steady Flow Pressure Distributions	480-503
	Unsteady Flow Pressure Distributions	504-519
VII.	Clean Wing + Underwing Pylon Store Panel Geometry	520
	Steady Flow Pressure Distributions	521-568
	Unsteady Flow Pressure Distributions	569-584

SUMMARY

This report presents results from analyses of steady and unsteady flows about several configurations involving the wing of the F-5 fighter airplane. The analyses were performed using higher order panels methods and the configurations analyzed included the following: the clean wing (both in an unbounded and in a wind tunnel wall bounded atmosphere), the wing with an external missile store mounted at the wing tip, and the wing with an external missile store mounted on a pylon at the lower surface of the wing. The flow Macn number ranged from 0.6 to 1.35 in steady flow and from 0.6 to 0.95 in unsteady flow. Each steady flow case is analyzed at three angles of attack (0.5°, 0.0°, -0.5°) while each unsteady flow case consisted of unsteady pitch oscillation about zero angle of attack.* The reduced frequency of the oscillation was in the range from 0.2498 to 0.3955. The computed results include chordwise pressure distributions along wing sections at eight spanwise locations from 18.1 to 97.7 per cent semispan. The results also include the coefficients of lift and pitching moment for each complete configuration as well as the coefficients of aerodynamic force and couple arising from the pressure on only the surface of the missile store.

* Some clarification here: steady solution was generated from the CAT II pilot code [subsonic, steady] and served as input to the subsonic unsteady pilot code.

INTRODUCTION

Steady and unsteady flows about the wing of the F-5 fighter airplane have been calculated using the panel methods described by references 1 and 2. Calculations are performed for several configurations. The configurations consist of the clean wing and the wing with several external store arrangements which are described in section 3. The results presented here are to be used as part of a larger study. In that study the F-5 wing configurations will be evaluated by alternative analytical methods as well as by wind tunnel testing. This report presents the results of the panel method analysis in the form of chordwise pressure distributions and in the form of aerodynamic forces and couples evaluated at selected reference points on the configurations. This report does not provide a discussion of the results nor does it draw conclusions; it presents only the computed results and the basis of the computations.

Section 4 contains a description of the analytical method. There is a brief description of the flow theory and the panel method for its evaluation. Those descriptions are not complete, and they are provided only as a point of contact with their complete descriptions appearing in refs. 1 and 2. Section 4 also contains those geometric details of the F-5 wing which are required for the panel method of analysis. Section 5 describes the aerodynamic surface paneling and the boundary conditions used in the computations. Section 6 presents the computed results.

DESCRIPTION OF THE CONFIGURATIONS EVALUATED

The configurations evaluated consist of the F-5 fighter airplane wing, figure 1*, accompanied by a missile attached to a launcher and mounted in either of two positions: (1) at the wing tip, and (2) suspended from a pylon below the wing surface, figure 2. Figure 3 provides the details of the launcher and of the pylon while figure 4 shows the details of the missile including the planforms of the fins.

The F-5 wing has an airfoil section which is constant with span and which has the upper and lower surface coordinates shown in figure 1. The wing section aft of the 40 percent chord point is symmetric about the wing reference plane. The wing tip has a fairing which increases the wing span by 0.025 meters when the tip launcher is removed. The reference semi-span of the wing, which is 0.6226 meters, does not include the tip fairing. The reference wing area is 0.2604 square meters.

Figure 2 shows the locations of three strain gage balances, which were used in wind tunnel tests to measure the aerodynamic force and couple acting on the launcher and the missile. Figure 2 also shows the coordinate system which is used as the reference frame for the computations. The origin of this system is seen to be located at the apex of the wing; and the position of the missile, in each of its two positions, is described in figure 2 by identifying the coordinates of the missile forebody nose relative to the wing apex.

The dimensions shown on figures 1 through 4 are the dimensions of a wind tunnel model of the F-5 wing. The model was tested in a wind tunnel having a rectangular test section whose dimensions relative to the model are shown by figure 5.

^{*} Figures are located on pages 34 thru 584.

4. ANALYTICAL METHOD

4.1 PROBLEM FORMULATION

The theoretical model used in the calculations is based on the assumptions that both the steady and unsteady flows are small disturbance flows, references 1 and 2. Thus, a steady component of flow is approximated by a potential, ϕ , satisfying the following flow equation:

while an unsteady component of flow is approximated by a complex potential amplitude, ϕ^* , satisfying the following flow equation:

$$\beta^2 \phi^*_{xx} + \phi^*_{yy} + \phi^*_{zz} - 2\bar{\omega} M_0^2 \phi^*_{x} + (\bar{\omega}^2) M_0^2 \phi^* = 0$$
 (2)

where

$$e^2 = 1 - M_0^2, \tag{3}$$

 M_0 = freestream Mach number,

$$\bar{\omega} = \omega/U_0, \tag{4}$$

 $\mathbf{U_0}$ = freestream velocity magnitude, and

 ω = circular frequency of the unsteady flow component.

The steady flow boundary condition at aerodynamic surfaces, reference 1, is given by

$$\vec{W} \cdot \hat{n} = 0 \tag{5}$$

where \overrightarrow{W} is the first order approximation to the steady mass flux vector given by the following expression (which may be developed from the linearized Bernoulli equation in steady-state form plus a first order perturbation of the density*);

$$\overrightarrow{W} = \rho_0 \left[\left(U_0 + \beta^2 \phi_x \right) \hat{i} + \phi_y \hat{j} + \phi_z \hat{k} \right], \tag{6}$$

and \hat{n} is a unit vector normal to the surface. The disturbance pressure and the aerodynamic forces are computed assuming that the pressure coefficient is related to the velocity potential by the following second order equation:

$$C_{p} = -(\frac{1}{U_{0}})2 \left[2U_{0} \phi_{x} + \overrightarrow{\nabla} \phi \cdot \overrightarrow{\nabla} \phi - M_{0}^{2} (\phi_{x}^{2})\right]$$
 (7)

where $\vec{v} = \vec{\nabla} \phi$ represents the steady disturbance velocity.

In the case of oscillatory unsteady flow, the total velocity potential is given by

$$\Phi = U_0 \times + \phi + R (\phi^* e^{i\omega t})$$
 (8)

where R() denotes the real part, ϕ denotes the mean steady flow perturbation potential, and ϕ^* denotes the complex amplitude of the unsteady perturbation velocity potential which must satisfy eqn. (2). The aerodynamic surface boundary condition for the unsteady component of flow, reference 2, is given by

$$\vec{w}^* \cdot \hat{n} = -\vec{W} \cdot (\vec{e}^* \times \hat{n}) + \rho U_0 \vec{\omega} \vec{D}^* \cdot \hat{n} i$$
 (9)

where

$$\vec{w}^* = \rho_0 \left(\vec{\nabla} \phi^* - M_0^2 \left(i \bar{\omega} \phi^* + \phi_X^* \right) \hat{i} \right) \tag{10}$$

* See reference 3 for pertinent background information

= complex amplitude of the unsteady disturbance mass flux vector,

 ρ_0 = freestream fluid mass density,

 \overrightarrow{D}^* = complex amplitude of the unsteady displacement of the aerodynamic surface,

$$\vec{\Theta}^* = 1/2 \ \vec{\nabla} \times \vec{D}^* \tag{11}$$

= first order approximation to the complex amplitude of unsteady surface rotation, and

$$\rho = \rho_0 \left(1 - \frac{M_0}{U_0} \phi_X \right) \tag{12}$$

= fluid mass density in the steady component of flow

In the numerical implementation, equation 9 was imposed directly on the wing, launcher pylon, and missile fins. On the thick missile body it was imposed indirectly by requiring that the perturbation potential remain zero inside the missile body, combined with the imposition of an oscillatory amplitude of the surface source strength so as to create the conditions required by equation 9 on the exterior surface of the missile body.

The unsteady pressure coefficient is shown by reference 2 to have a complex amplitude related linearly to the complex amplitude of the unsteady velocity potential. The relationship is as follows:

$$C_{p}^{*} = -\frac{2}{U_{0}} \left[i \overline{\omega} \rho \phi^{*} / \rho_{0} + (\overline{W} / \rho_{0} U_{0}) \cdot \overline{\nabla} \phi^{*} \right]$$
 (13)

This expression was used to evaluate the pressure at the surface of the missile body. At all other surfaces (namely, those of the wing, the launcher, the pylon, and the missile fins) the unsteady pressure coefficient was evaluated using the following expression:

$$C_{p}^{\star} = -\frac{2}{U_{0}}(i\bar{\omega} \phi^{\star} + \phi_{\chi}^{\star}) \tag{14}$$

The boundary conditions at the aerodynamic surfaces are approximated by truncated Taylor series expansions. In the case of the missile body, the expansion is about the mean steady location of the surface, Appendix B of ref. 2; while, in the case of all other surfaces, the expansion is about a reference surface which is either planar or cylindrical and which is generated by a straight line parallel to the freestream direction. In the case of these other surfaces, the unsteady flow boundary condition, shown as eqn. (9), reduces to the following expression evaluated at the reference surface:

$$\vec{w}^* \cdot \hat{n} = -\rho_0 \left[\vec{U}_0 \cdot (\vec{e}^* \times \hat{n}) - U_0 \vec{\omega} \vec{D}^* \cdot \hat{n} \right]$$
 (15)

where $\hat{\mathbf{n}}$ is a unit vector normal to the reference surface. Similarly, the boundary condition associated with the mean steady component of flow is expressed by eqn. (5) linearized in the conventional manner about a mean wing plane.

For the case of pitch oscillation the complex amplitude of unsteady surface displacement at any point (x,z) on the surface is given by

$$\vec{D}^* = \Theta_0 [(z - z_0) \hat{i} - (x - x_0) \hat{k}]$$
 (16)

where θ_0 is the maximum angle of the pitching motion, (x_0, z_0) is the location of the pitch axis, and where \hat{i} , \hat{j} , \hat{k} represent the unit base vectors of the coordinate system. The pitch rate, Q, is given by

$$Q = iw \Theta_0 R (e^{iwt})$$
 (17)

where $R(\)$ denotes the real part. The surface rotation shown by eqn. (11) is computed from eqn. (16) to find

$$e^* = e_0 \hat{j}. \tag{18}$$

At all surfaces except the missile body surface, the vector $\hat{\mathbf{n}}$, normal to the reference surface is such that

$$\hat{n} \cdot \hat{i} = 0$$
:

hence, using this result and substituting eqs. (16) and (18) into eqn. (15), the boundary condition is found to be as follows:

$$\vec{w}^* \cdot \hat{n} = - \rho_0 U_0 \Theta_0 n_z \left[1 + i \overline{\omega} (x - x_0) \right]$$
 (19)

where this expression is evaluated at the reference surfaces of the configuration components.

The boundary conditions associated with the mean steady flow satisfy eq. (5) on the missile body, and they are linearized in the conventional manner for all other surfaces.

4.2 NUMERICAL METHOD

The numerical method used is the higher order panel method of ref. 1 and 2 wherein the velocity potential is expressed in terms of sources and doublets distributed over the aerodynamic surfaces. The aerodynamic surfaces are subdivided into small panels. On each panel the strength of the source distribution is a linear function of the coordinates of a point on the panel, i.e.,

$$\sigma(Q) = \sigma_0 + \sigma_{\xi} \xi + \sigma_{\eta} \eta \qquad (20a)$$

where ξ , η are the coordinates of the point Q lying on the panel. Similarly, the strength of the doublet distribution on each panel is a quadratic function of the panel surface coordinates, i.e.,

$$\mu(Q) = \mu_0 + \mu_{\xi} \xi + \mu_{\eta} \eta + \frac{1}{2} \mu_{\xi\xi} \xi^2 + \mu_{\xi\eta} \xi \eta + \frac{1}{2} \mu_{\eta\eta} \eta^2 \quad (20b)$$

Equations (20a) and (21b) describe the strength distribution of steady sources and doublets. Completely analogous expressions describe the complex amplitudes of the strength distributions of unsteady sources and doublets, namely:

$$\sigma^{\star}(0) = \sigma_{0}^{\star} + \sigma_{\xi}^{\star} \xi + \sigma_{\eta}^{\star} \eta \tag{21a}$$

$$\mu^{*}(Q) = \mu_{0}^{*} + \mu_{\xi}^{*}\xi + \mu_{\eta}^{*}\eta + \frac{1}{2}\mu_{\xi\xi}^{*}\xi^{2} + \mu_{\xi}^{*}\eta\xi\eta + \frac{1}{2}\mu_{\eta\eta}^{*}\eta^{2}$$
 (21b)

The source and doublet distribution coefficients in the right-hand members of eqns. (20) and (21) are related by a least squares method to the source and doublet strength at control points, references 1 and 2. The control points are located at panel centers and at the edge of a panel which forms part of the edge of a network, references 1 and 2.

5. PANEL METHOD MODEL

5.1 SURFACE PANELING

Figures 6 through 15 show the wing with two cases of external missile store: (1) mounted at the wing tip, and (2) mounted at the under wing pylon.

In both cases the wing paneling is coincident with the wing reference plane shown in figure 1. The launcher, when tip mounted, lies in the wing reference plane; and, when the launcher is under wing mounted, the launcher and pylon lie in a plane parallel with the freestream direction and normal to the wing reference plane. The missile body is a body of revolution whose generator, when the wing is at zero angle of attack, is parallel with the freestream. The missile fins are infinitesimally thin, planar surfaces intersecting the missile body at body generators at azimuth angles which are ninety degrees apart around the missile body.

Figure 16 shows the wing paneling consisting of thirteen panels in the chordwise direction and thirteen panels in the spanwise direction. The location of the edges of the panels in the chordwise direction relative to the wing leading edge are given by the following formula:

$$\xi_{\rm M} = 0.5c \left[1 - \cos \left(\pi S_{\rm M}\right)\right]$$
 (22)

where c is the local chord length and

$$S_{M} = (M-1)/(MMAX-1)$$
 (23)

where

$$M = 1, 2, 3, \dots, MMAX$$

MMAX = 11.

Three additional panel edges are introduced to provide panel edges intersecting the pylon at its ends and providing the panel density (in the region of the pylon) necessary to represent the pylon induced interference flow. The panel edges are located at the streamwise locations shown in Table 1*.

^{*} Tables are located on pages 23 thru 32.

The spanwise locations of the panel edges are computed using the following equation:

$$\eta_{N} = b \sin \left(S_{N} \pi/2 \right) \tag{24}$$

where b is the span of the wing shown in figure 1 including the tip fairing (viz., b = 0.6476 meters) and

$$S_{N} = (N-1)/(NMAX-1)$$
 (25)

for

$$N = 1, 2, 3..., NMAX$$

NMAX = 11.

Three additional spanwise edges are inserted to accommodate the intersection of the underwing pylon and the tip launcher. This leads to panel edges at the locations shown in Table 2.

where c_R (= 0.6396 meters) denotes the wing root chord length, figure 1.

Wake surfaces trail downstream from each of the following surfaces: the wing, the pylon, the launcher, the aft end of the missile body, and each of the missile fins. In all cases the wake surface is a cylindrical surface whose generator is parallel with the freestream. These surfaces are paneled such that the panel spacing in the freestream direction is equal to one-sixteenth of the wave length of the doublet strength harmonic variation along the wake surface. The doublet strength varies as follows (ref. 2, eqn. (5.28)):

$$\mu^*(x,s) = \mu^*(c,s)[\cos(\omega(x-c)) + i \sin(\omega(x-c))]$$
 (26)

where $\mu^*(c,s)$ is the doublet strength at the trailing edge of the surface from whence the wake emanates and (x-c) is the distance downstream from the trailing edge. The wave length of the harmonic variation is

$$L_u = 2 \pi/\omega;$$

hence, the streamwise panel spacing is chosen as

$$2\pi/(16\omega)$$

This panel spacing is chosen so that the quadratic distribution of doublet strength on each panel, eqn. (21), will accurately approximate the harmonic variation shown by eqn. (26). Each wake surface extends downstream 7.5 root-chord lengths.

The wind tunnel walls shown by figure 5 are represented by panel networks extending from x = -3.0 to $\dot{x} = 5.0$; thus, the tunnel walls extend 1.5 root-chord lengths upstream and downstream of wing. The tunnel walls are treated as solid and a wake surface extends downstream from each wall. The tunnel is modeled like a ring-wing having zero incidence to the undisturbed freestream.

5.2 STEADY FLOW BOUNDARY CONDITIONS

As noted in the preceeding, the configurations are constructed from six types of components: (1) the wing, (2) pylon, (3) launcher, (4) missile body, (5) aft fins, and (6) forward fins. All of these components, except the missile body, are approximated by thin-wing theory, cf., chapter 5 of reference 4; thus, their aerodynamic surface boundary conditions are expressed in terms of a truncated Taylor series expansion about mean, defining surfaces. Equation (5) becomes

$$\frac{1}{\rho_0 U_0} \stackrel{\leftarrow}{w} \cdot \hat{n} = -n_{\chi} \tag{27}$$

where:

$$\frac{\vec{w}}{\rho_0} = \beta^2 \phi_X \hat{i} + \phi_Y \hat{j} + \phi_Z \hat{k} = \text{perturbation mass flux vector}$$
 (28)

 \hat{n} is a unit vector normal to the mean surface of definition; and n_{χ} is the x-axis component of the actual, aerodynamic surface normal. Letting α represent angle of attack in radians and letting the airfoil surface be decomposed into camber plus thickness, so that $(\pi/2 - \alpha - \alpha_{C} \mp \alpha_{t})$ approximates the angle between the aerodynamic surface normal and the x axis, eqn. (27) becomes

$$\frac{1}{\rho_0 U_0} \overrightarrow{w} \cdot \hat{n} = -\cos \left(\frac{\pi}{2} - \alpha - \alpha_c + \alpha_t \right) \approx -\alpha - \alpha_c + \alpha_t$$
 (29)

where

$$\vec{w} = \vec{W} - \rho_0 U_0 \hat{i}$$

and where the plus and minus sign before α_t is a result of the symmetry of the thickness shape relative to the mean defining surface. Letting the strength of the source distribution at the mean, defining surface be given by (p. 129 of ref. 4)

$$\frac{\sigma}{U_0} = -2\alpha_t \tag{30}$$

eqn. (29) reduces to eqn. (30) plus the following:

$$\frac{1}{\rho_0 U_0} \vec{w} \cdot \hat{n} = -\alpha - \alpha_c \tag{31}$$

which is the boundary condition which must be satisfied at the mean, defining surfaces.

The wing, the pylon, and the launcher were treated as having thickness using eqn. (30) but the thickness of the missile fins was completely ignored. For the wing the thickness and camber are computed from the airfoil data shown on figure 1. The wing boundary conditions, shown by eqns. (30) and (31), are applied at control points located on the wing planform edges and at the centers of the panels shown by figure 16. The values of the camber and thickness slope angles at control points along a typical chordwise wing section are shown in Table 3, where $\xi_{\rm M}$ is the distance from the wing leading edge to the Mth control point and C is the chord. Neither the pylon nor launcher have camber but they have the thickness shapes shown in figure 3.

At the missile body surface at points indefinitely near the surface but exterior to the missile body the flow incidence is,

$$-\overrightarrow{U}_{0}$$
 . \widehat{n}

where \overrightarrow{U}_0 is the freestream velocity vector, is set equal to the strength of sources distributed on the missile surface, i.e.,

$$\sigma = -\overrightarrow{U}_0 \cdot \widehat{n}$$
 (32)

At points indefinitely near the surface but interior to the missile body the disturbance velocity potential is set to zero by imposing a Dirichlet boundary condition. As a result of satisfying these two requirements, the boundary condition shown in eqn. (5) is satisfied at the surface of the missile body and the flow interior to the body is the undisturbed freestream.

As shown by ref. 5, section 1.3, the general form of the boundary condition, which can be applied at a control point of the panel method, is given by the following equation:

$$C_{ij}(\overrightarrow{w}_{ij} \cdot \hat{n}) + \overrightarrow{T}_{ij} \cdot \overrightarrow{v}_{ij} + D_{ij}\phi_{ij} + C_{\ell}(\overrightarrow{w}_{\ell} \cdot \hat{n}) + \overrightarrow{T}_{\ell} \cdot \overrightarrow{v}_{\ell} + D_{\ell}\phi_{\ell} = BET$$
 (33)

where \overrightarrow{w} , \overrightarrow{v} , ϕ , respectively, represent the mean steady values of the disturbance mass flux, velocity, and potential. The subscripts u and ℓ , respectively, imply evaluation at the upper and lower sides of a surface when the upper side is the side where $\widehat{\mathbf{n}}$ is positive. The coefficients $C_{\mathbf{u}}$, C_{ℓ} , $\overrightarrow{T}_{\mathbf{u}}$, $\overrightarrow{T}_{\ell}$, D_{ℓ} , and $D_{\mathbf{u}}$ as well as the value of BET are specified by the user of the panel method computer program. The values of these quantities are specified by exercising the options listed in tables 2.2 and 2.3 of ref. 5. The option choice and the types of networks (ref. 5, section 2.4) chosen for each configuration component are shown in Table 4.

The option NROPT2=1 indicates that the value of BET, appearing in eqn. (33) for the second boundary condition is supplied by the subroutine called INPUT. The values supplied were as follows:

BET =
$$\alpha_C - \alpha(IACASE)$$
 for IACASE = 1,2,3 (34)

where

$$\alpha(1) = 0.0^{0}$$

$$\alpha(2) = -0.5^{\circ}$$

$$\alpha(3) = 0.5^{0}$$

The values of α_C (i.e., the camber surface slopes) are given by table 3. Similarly, NROPT1=1 indicates that the value of BET for the first boundary condition is supplied by INPUT. The values supplied were

BET =
$$2.0\alpha_{t}$$

where the values of α_t are given by table 3. The option NROPT2=5 indicates that the value of BET for the second boundary condition is computed in subroutine CBET. Subroutine CBET performs the following computation:

BET =
$$-n_{\chi} \cos \alpha (IACASE) - n_{Z} \sin \alpha (IACASE)$$
 (35)
for IACASE = 1,2,3

where \mathbf{n}_{χ} and \mathbf{n}_{z} are the x and z axis components of the unit vector normal to the surface.

5.3 UNSTEADY FLOW BOUNDARY CONDITIONS

Equations (9) and (15) show the unsteady flow boundary conditions used. Eqn. (9) is applied for control points at the missile body surface while eqn. (15) is applied at the mean, defining surfaces of all other components. The surface displacement \vec{D}^* and rotation \vec{e}^* for the case of pitch oscillation are shown by eqn. (16) and (18). Eqn. (19) shows the result of substituting these expressions into eqn. (15); eqn. (19), therefore, represents the boundary condition which is applied everywhere except at the missile body surface. Substituting eqns. (16) and (18) into eqn. (9) yields

$$\vec{w}^* n = -\rho_0 \left[(U_0 + \beta^2 \phi_X) n_z - \phi_z n_X \right]$$

$$-i(1 - \frac{M_0^2}{U_0} \phi_X) - (z - z_0) n_X - (x - x_0) n_z \right] \theta_0$$
(36)

This expression describes the boundary condition applied at control points on the missile body surface; hence, $\phi_{\rm X}$ and $\phi_{\rm Z}$ represent derivatives of the mean steady flow potential evaluated at those control points.

The general form of the boundary condition in unsteady flow has the same form as (33) except that BET, \vec{w} , \vec{v} , and ϕ are all complex. The choice of network type and the boundary condition option used to determine the coefficients of the unsteady flow form of eqn. (33) for each configuration component are shown in Table 5. The option implied by NROPT1 and NROPT2 is that the real and imaginary parts of complex BET, see eqn. (33), are supplied by subroutine CBET. If the control point is on the missile body surface,

subroutine CBET sets BET equal to the right-hand side of eqn. (36) evaluated at the control point. If the control point is at any other surface, BET is set equal to the right-hand side of eqn. (19). The unsteady flow boundary condition applied to the missile base is indential to the base boundary condition in steady flow, where it correctly produces a Kutta condition off the aft end of the missile body. Analysis of the unsteady results shows that we did not achieve a Kutta condition in unsteady flow and upon reflection we now believe that a different base boundary condition is required in unsteady flow. Unfortunately we have not had time to derive and implement such a boundary condition.

COMPUTED RESULTS

Seven configurations were evaluated; they are listed in Table 6.

Each configuration was evaluated at three steady angles of attack (viz., 0.0° , 0.5° , and -0.5°) measured from the wing reference plane, figure 1. Each configuration was also evaluated at unsteady pitch oscillation about a spanwise axis at 50 percent of the root chord, figure 9. The maximum amplitude of pitch is

$$\Theta_{\text{max}} = 0.00199 \text{ radians} \tag{38}$$

and the frequency of the oscillations is 40 Hz. so that

$$ω = 80 π radians/second$$
 (39)

Also, the freestream velocity is given by

$$U_0 = M_0 a_0 \tag{40}$$

where

$$a_0 = 338.7 \text{ meters/second}$$
 (41)

is the freestream speed of sound so that the reduced frequency of the pitch oscillation is

$$\kappa = .2373/M_{0} \tag{42}$$

where the characteristic length has been chosen to be one-half of the wing root chord.

The Mach numbers at which the configurations were evaluated are as shown in Table 7.

6.1 AERODYNAMIC SURFACE PRESSURE DISTRIBUTIONS

The aerodynamic surface pressure coefficient (both steady and unsteady) was evaluated along chordwise lines at the eight spanwise stations shown in figure 17. As indicated by figure 17 these eight chordwise sections are the locations where pressure orifices were positioned for wind-tunnel tests of the wing. The upper and lower surface pressure coefficients (C_p and C_p) were evaluated using eqns. (7) and (13). The lifting pressure coefficient namely;

$$\Delta C_{p} = C_{p_{u}} - C_{p_{\ell}} \tag{43}$$

is also evaluated. In the case of unsteady flow the real and imaginary parts of the pressure coefficient complex amplitude were normalized by the maximum amplitude of the pitch oscillation; thus,

is computed as a basis for evaluating the unsteady pressure coefficient corresponding to a unit (i.e., one radian) amplitude of pitch oscillation.

The paneled geometry used for case 1 is displayed in figure 18. The steady flow pressure distributions for this case are shown in figures 19-210 and the unsteady flow pressure distributions are shown in figures 211-274. The paneled geometry used for case 2 is displayed in figure 275. The steady flow pressure distributions for this case are shown in figures 276-323 and the unsteady flow pressure distributions are shown in figures 324-355. The paneled geometry used for case 3 is displayed in figure 356. The steady flow pressure distributions for this case are shown in figures 357-380 and the unsteady flow pressure distributions are shown in figures 381-396. The paneled geometry used for case 4 is displayed in figure 397. The steady flow pressure distributions for this case are shown in figures 398-421 and the unsteady flow pressure distributions are shown in figures 422-437. The paneled geometry for case 5 is displayed in figure 438. The steady flow pressure distributions for this case are shown in figures 439-462 and the unsteady flow pressure distributions are shown in figures 463-478. The paneled geometry for case 6 is displayed in figure 479. The steady flow pressure distributions for this case are shown in figures 480-503. The unsteady flow pressure distributions are shown in figures 504-519. paneled geometry for case 7 is displayed in figure 520. The steady flow pressure distributions for this case are shown in figures 521-568. The unsteady flow pressure distributions are shown in figures 569-584.

The points shown graphically and tabularly on figures 18-584 are a result of a linear interpolation of the data computed by the panel methods. The panel methods compute the values of the pressure coefficient at the centers of the wing panels shown by figure 16. The spanwise locations of the panel centers do not coincide with the spanwise locations of the pressure orifices shown by figure 17. The values shown in figures 18-584 are the result of linear interpolation between the panel method values at the panel centers at

either side of the wing section where the pressure is evaluated in these figures.

6.2 MISSILE STORE AERODYNAMIC FORCE AND MOMENT

Tables 8-11 contain the steady and unsteady aerodynamic force and moment coefficients which evaluate the airloads on each configuration and on the missile stores at the centers of balance locations shown on figure 2. The coefficients are computed from the following formulas:

$$C_y = \frac{1}{S_R} \iint_S C_p \hat{n} \cdot \hat{j} ds$$
 ~ side force (44)

$$C_z = \frac{1}{SR} \iint_S C_p \hat{n} \cdot \hat{k} ds$$
 ~lift force (45)

$$C_{m} = \frac{1}{S_{R}C_{R}} \quad \iint_{S} C_{p} \left[(\overrightarrow{R} - \overrightarrow{R}_{R}) \times \hat{n} \right] \cdot \hat{j} \, ds \sim \text{pitching moment} \quad (46)$$

$$C_{\ell} = \frac{1}{S_{R}b_{R}} \iint_{S} C_{p} [(\overrightarrow{R} - \overrightarrow{R}_{R}) \times \hat{n}] \cdot \hat{i} ds \sim rolling moment$$
 (47)

where C_p is the pressure coefficient from ean. (7) in steady flow and from eans. (13) and (14) in unsteady flow; $\hat{\mathbf{n}}$ is a unit vector normal to the aerodynamic surface S; $\hat{\mathbf{i}}$, $\hat{\mathbf{j}}$, $\hat{\mathbf{k}}$ are the unit base vectors of the coordinate system shown on figure 2; $\widehat{\mathbf{R}}_R$ is the position of the balance center (labeled "center of balance" in figure 2) relative to the origin of the coordinate system; S_R (= 0.2604 sq. meters) is the reference area of the wing; \mathbf{b}_R (= 0.6224 meters) is the reference semi-span; and C_R (= 0.4183 meters) is the mean reference chord.

Table 8 shows the lift coefficient and pitching moment coefficient for each configuration at the three steady angles of attack: 0.5° , 0.0° , -0.5° . The lift force is regarded as being in the direction of the z coordinate line

(figure 2) and the pitching moment is about a spanwise axis at the half root chord. The surface of integration, S, in the case of this table of data, is the entire aerodynamic surface of the wing and missile store. The position vector \overrightarrow{R}_R is given by

$$\hat{R}_{R}$$
 = .3198 (meters) \hat{i} (47)

For Case 1 the lift force obtained from the wake circulation is shown in parentheses. This method is known to be quite accurate and the disagreement with integrated values can be attributed to coarse leading edge paneling.

Table 9 shows the complex amplitudes of unsteady lift and pitching moment coefficient for each configuration. These coefficients correspond to pitch oscillation with a maximum amplitude of one radian. The surface of integration, S, is the entire aerodynamic surface and the reference position vector \vec{R}_R is, again, given by eq. (47).

Table 10 shows the side and lifting force coefficients and the rolling and pitching moment coefficients for the missile store when the wing is at a steady angle of attack. In each case eqs. (44 - 47) are evaluated choosing the surface of integration to be that of the missile and the missile launcher. In the case of the tip mounted missile

$$\hat{R}_R = .48 \text{ (meters) } \hat{i} + .635 \text{ (meters) } \hat{j}$$
 (48)

in the case of the under wing, pylon mounted missile

$$\vec{R}_R = .43 \text{ (meters) } \hat{i} + .477 \text{ (meters) } \hat{j} - .066 \text{ (meters) } \hat{k}$$
 (49)

Table 11 shows the complex amplitudes of the corresponding unsteady force and moment coefficients.

7. CONCLUSIONS

Numerical calculations for steady and unsteady flow have been made for a fighter aircraft wing with external stores. These calculations were made for harmonic pitch oscillations about a line through the midpoint of the root chord for reduced frequencies of up to k=0.4. Calculations took the form of pressure distributions for both the upper and lower wing surface. Force coefficients were also calculated over the Mach range of M=0.6 to M=1.35. These data are provided for comparisons of the numerical calculations with other numerical methods and with experimenta' results.

一片 网络花花花

REFERENCES

- Ehlers, E. F., Epton, M. A., Johnson, F. T., Magnus, A. E., and Rubbert, P. E.: "A Higher Order Panel Method for Linearized Supersonic Flow," NASA CR-3062, 1979.
- 2. Dusto, A. R. and Epton, M. A.: "An Advanced Panel Method of Analysis of Arbitrary Configurations in Unsteady Subsonic Flow," NASA CR-152323, 1980.
- 3. Ward, G. N., "Linearized Theory of High Speed Flow," Cambridge University Press, 1955.
- 4. Ashley, H. and Landahl, M.: "Aerodynamics of Wings and Bodies," Addison-Wesley, 1965.
- Moran, J., Tinoco, E. N., and Johnson, F. T.: "User's Manual,
 Subsonic/Supersonic Advanced Panel Pilot Code," NASA CR-152047, 1978.

Table 1 Chordwise Coordinates of Panels on Wing Surface

M	ξ _M /c
1	0.0
2	0.02447
3	0.09549
4	0.2061
5	0.2504
6	0.3455
7	0.5000
8	0.6545
9	0.7032
10	0.7362
11	0.8117
12	0.9045
13	0.9755
14	1.0000

Table 2 Spanwise Coordinates of Panels on Wing Surface

N	2 _{nN} /c _R
1	0.0
2	0.3168
3	0.6258
4	0.9193
5	1.1903
6	1.4319
7	1.4916
8	1.5520
9	1.6383
10	1.8043
11	1.9259
12	1.9468
13	2.001
14	2.0250

Table 3 Camber and Thickness Angle of Slope of Wing Airfoil

M	ξ _M /C	α_{C} , radians	α _t , radians
1	1.0000	0.0000	~
2	0.9875	0.0000	-0.06119
3	0.9389	0.0000	-0.06118
4	0.8068	0.0000	-0.06112
5	0.7735	0.0000	-0.05637
6	0.7199	0.0000	-0.04572
7	0.6788	0.0000	-0.03770
8	0.5754	0.0000	-0.02404
9	0.4218	0.0000	-0.002439
10	0.2987	0.0037	0.02214
11	0.2291	0.01612	0.03472
12	0.1518	0.03039	0.05127
13	0.06126	0.05775	0.0933
14	0.01289	0.07366	0.3164
15	0.0000	0.078	

Table 4 Steady Flow Boundary Condition Options

COMPONENT	NTS	NTD	NLOPT1	NROPT1	NLOPT2	NROPT2
wing	1	12	5 (0	1 0	4	1 1)*
launcher	1	12	5 (0	1 0	4 4	5 5)*
pylon	1	12	5 (0	1 0	4 4	5 5)*
missile body	1,	12	5 (0	3 0	7 7	2 2)**
missile body base closure	1	12	6 (0	2 0	7 7	2 2)*
missile fins	0	12	0	0	4	5
wind tunnel walls	0	12	0	0	4	3
wakes	0	18	0	0	4	3

Network edge control point choice of options where they differ from the panel center control point choice.

**

At network edges abutting a missile body base closure network, NLOPT2 = 3.

	Table 5	Unsteady	Flow Bound	lary Condi	tion Options	•
COMPONENT	NTS	NTD	NLOPT1	NROPT1	NLOPT2	NROPT2
wing	0	12	0	0	4	5
launcher	0	12	0	0	4	5
pylon	0	12	0	0	4	5
missile body	1	12	5 (0	5 0	7 7	2 2)*
missile body base closure	1	12	6 (0	2 0	7 7	2 2)**
missile fins	0	12	0	0	4	5
wind tunnel walls	0	12	0	0	4	3
wakes	0	18	0	0	4	3

At network edge control points on network edge abutting a missile body base closure network.

Network edge control point.

Table 6 Configuration Indentification Numbers

- 1. Clean wing including tip fairing, figure 1.
- Clean wing including tip fairing and mounted in a wind-tunnel, figure 5.
- 3. Wing without tip fairing but with tip launcher.
- 4. Case 3 plus tip missile body.
- 5. Case 4 plus aft missile fins.
- 6. Case 5 plus canard fins.
- Case 1 plus under wing pylon, launcher and missile (including both aft and canard fins).

Table 7 Flow Evaluation Conditions

Configuration	Steady	Evaluation	Unsteady Evaluation
Number	Mach	Numbers	Mach Numbers
1	.6, .8, .9,	.95, 1.05, 1.1, 1.35	.6, .8, .9, .95
2	.6, .8		.6, .8
3	.8		.8
4	.8		.8
5	.8		.8
6	.8		.8
7	.6, .8		.6

Table 8 Steady Lift and Pitching Moment Coefficients

	50	0.0	.50	50	0.0	.50	50	0.0	.50
	[]	C1, M = .6			C1, M = .8			C1, M = .9	
2)	03182 .00101 (03650) (00473)	.00101	.03383	03459 .00143 (03939) (00432)	.00143	.03746	03670 (04161)	03670 .00222 (04161) (00354)	.04115
ٿ	00935	00721	00508	01128	00889	.03075	01331	01065	00800
	23	C2, M = .6		J	C2, M = .8				
CZ	03378	.00075	.03535	03658	.00137	.03949			
ٿ	00925	00714	00501	01093	00868	00639			
				0	C3, M = .8				
2)				- 103452	.00189	.03847			
ٿ				00658	00875	01092			
					C4, M = .8				
25				03883	.00143	.04137			
ٿ				00576	00873	01167			
					C5, M = .8				
2)				04095	.00121	.04355			
رس				00923	00848	00770			

Table 8 Concluded

0.0 0							C1, M = 1.10	321) (01405) (.03511)	03071			
.5050		.04371	01249		.03358	00955		.0569c05902 (.05189) (06321)	0320802675		.00023	
0.0	C6, M = .8	.00116	00865	C7, M = .8	300326	00917	C1, M = 1.05	.00516	02955	C1, M = 1.35	03488	
50		04119	00481		303993	5 00877		704666 1) (05125)	002701		707000	
0.0				9. =	00245 .03123	0081500845	C1, M = .95	00320 .04437 00256) (.03781)	0122000930	= 1.2)3085 .01217)3247) (.01067)	
50				C7, M = .6	03608	00782	C1, M	03798 .00320 (04293) (00256)	01511(C1, M = 1.2	0738703085 (07562) (03247)	
		C ₂	Cm		2	۳		25	ٿ	•	23	

Table 9 Unsteady Lift and Pitching Moment Coefficients

	laule 9	onsteady Lift and F	ruching moment Coeffic	nents
	C1, M = .6	C1, M = .8	C1, M = .9	C1, M = .95
			4.5043 .4646	
C _m			28187893	59699292
	C2, M = .6			
_	3.7649 1.0839			
c <mark>m</mark>	.35404645	.33465769		
		C3, M = .8		
c _z *		4.1001 .7014		
c _m		.31395376		
		C4, M = .8		
C _z *		4.4216 .6556		
C _m		24676399		
		C5, M = .8		
c _z *		4.6544 .5680		
c _m *		39176180		
		C6, M = .8		
c _z *		4.7840 .4629		
c _m *		47095619		
		C7, M = .8		
c*		3.6673 1.1413		
c _m *		.07885813		

Table 10 Steady Force and Moment Coefficients for Missile Store

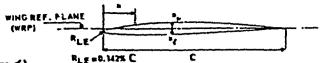
		•				
		C3, M = .6			C3, $M = .8$	
	$\alpha =5$	$\alpha = 0$	$\alpha = .5$	$\alpha =5$	$\alpha = 0$	$\alpha = .5$
c_y				0	0	0
$C_{\mathbf{Z}}$				00076	00007	.00063
c ₂				0	0	0
c_{m}				00013	00005	.00003
					C4, M = .8	
c_y				00076	00086	00081
c_{z}				00196	00019	.00158
Ce				00004	00001	00003
c_{m}				00052	00013	.00026
					C.5, M = .8	
c_y				00455	00460	00459
$C_{\mathbf{Z}}$				00317	00028	.00261
C _L				00341	00030	.00281
c_{m}				00070	00015	00323
					C6, M = .8	
c_y				00458	00460	00460
$C_{\mathbf{Z}}$				00323	00029	.00265
C&				00018	00002	.00014
$C_{\mathbf{m}}$				00073	00016	.00041
		C7, M = .6			C7, M = .8	
c_y	00299	00196	00095	00374	00254	00137
Cz	.00466	.00493	.00519	.00546	.00574	.00601
C &	00015	00009	00005	00018	00013	00007
Cm	00288	00248	00209	00318	00278	00236

Table 11 Unsteady Force and Moment Coefficients for Missile Store

	Idole II	onsceady	TOICE OIL	d Montent
			С3,	M = .8
C*			0	0
C*			.0612	.0096
C* C* C* C*			.0626	.0098
c _m			.0232	0012
			C4,	M = .8
c*			0022	.0003
C _z *			.1652	.0270
c*			.0034	.0009
C'y C'z C'&			.05490	00083
			C5,	M = .8
c <u>*</u>			0836	.0260
c*			.2955	.0176
C _y C _z C e			.0168	0001
c _m *			.0298	0083
			C6,	M = .8
c*			.3203	1194
-			.4191	0289
c *			.0230	0023
c* c* c* c*			.0233	0017
			C7,	M = .6
c*			.0998	0008
c*			.0421	.0420
C*y C*z C*			.0049	0004
*				

.0290 -.0414

33



AEROFOIL CO-ORDINATES (IN \$)

₽ /C	*,/C	*f/C	./c	•,/c	2/30	-/C	. /C(- Z(/C)	./C	. /CI-Zi/CI
8	-1.03300	-1.03300	14	1.42438	-1.97891	41	2.37730	71	1.74675
0.1	-0.85917	-1.19123	135	1.50900	-1.99811	42	2.35720	72	1.70213
0.2	-0.78409 .	-1.25078	136	1.50097	-2.01730	143	2.39372	73	1.65530
0.3	-0.72529	-1.29413	117	1.66447	-2.03650	144	2.30005	74	1.60623
0.4	-0,67494 -	-1.32912	18	1.73574	-2.05568	145	2.38260	75	1.55497
0.5	-0.62999	-1.35879	129	1.80264	-2.07488	46	2.37496	76	1.50162
0.6	-0.58889	-1.38470	20	1.86588	-2.09407	47	2.34597	177	1.44631
0.7	-0.55074	-1.40774	l n	1.92499	-2.11326	48	2.35560	178	1.30974
0.8	-0.51409	-2.42655	22	1.98022	-2.13245	47	2.34357	79	1.33066
0.9	-0.48095	-1.44754	53	2.03144	-2.1514	150	2.33078	80	1.27067
1.0	-0.44861	-1,46502	24	2.07933	-2.17083	53	2.31633	91	1.21023
1.85	-0.37336	-1.50342	25	2-12334	-2.19002	52	2,30054	82	1.14913
1.50	-0.30440	-1.53608	36	2.16373	-2.20371	53	2.28341	83	1.00198
1.75	-0.24019	-3.56446	27	2.20056	-2.22640	193	2,26493	4	1.02680
2.00	-0.17980	-1.50950	126	2.23391	-2.24760	55	2.24512	1 95	0.96563
2.25	-0.12256	-1,61186	139	2,26384	-2.2677	196	2.22398	66	0.9045
2.50	-0.06801	-2.63204	130	2,290()	-2.20398	151	2,20152	81	0.64328
3.00	0.03448	-1.66716	31	2.31376	-2,30509	58	2.37774	86	0.78210
4.00	0.21918	-1.72230	32	2.33396	-2.32367	20	2,15263	87	0.7209)
5.00	0.38403	-1.76571	L L	2,35113	-2.3017	160	2.17472	90	0.65175
6.00	0.53408	-1.79977	Ж	2,36540	-2.35704	161	2,07840	71	a, sansa
7.00	0.67239	-1.82904	35	2.37693	-2.37079	62	2.06948	35	0.53740
8.00	0.80092	-1.05474	36	2.38588	-2,38202	63	2.03716	93	0.4762)
7.00	0.92107	-1.87001	37	2.39243	-2.39049	4	2.00755	34	0.42505
10	1,03386	-1.87966	38	2, 39681	-2.39614	65	1.97465	55	0.35386
11	1.14006	-1.92024	139	2.39924	-2.39915	46	1.94017	96	0.25770
12	3.24024	-3.94013	40	2.40000	-2.40000	67	1.90501	91	0°53127
13	3.33490	-1.95962		·		68	1.06814	96	0.17(35
			•			19	1.82961	33	0.10718
						170	1.78920	μœ	0.04800

Co-ordinates of the aerofoil of the wing

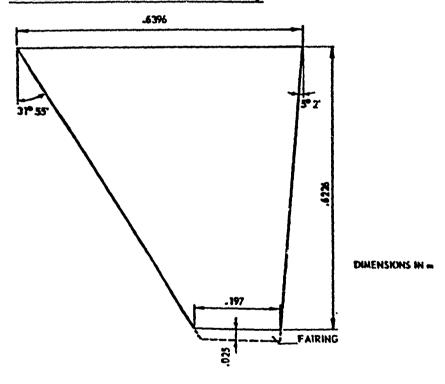


FIGURE 1 DIMENSIONS OF THE WING

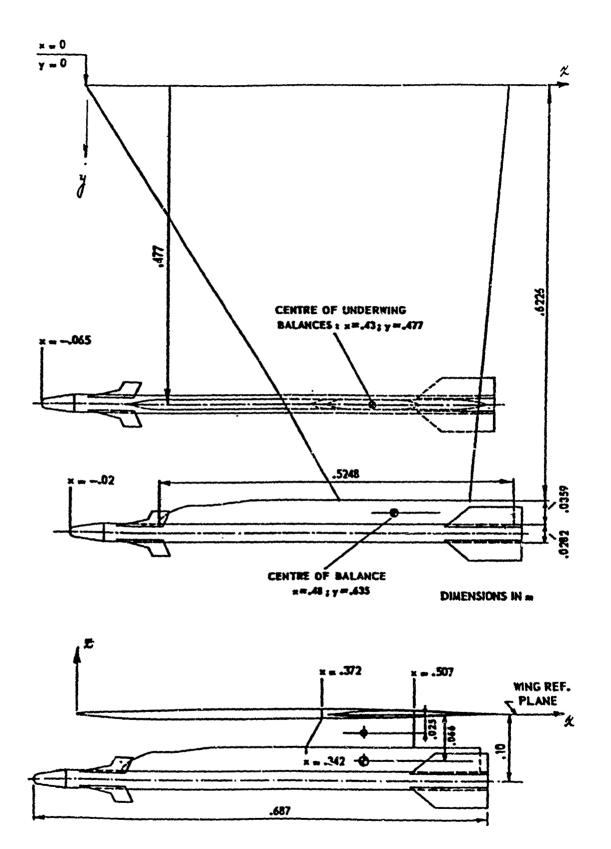


FIGURE 2 POSITION OF THE STORE AND STRAIN GAGE BALANCES

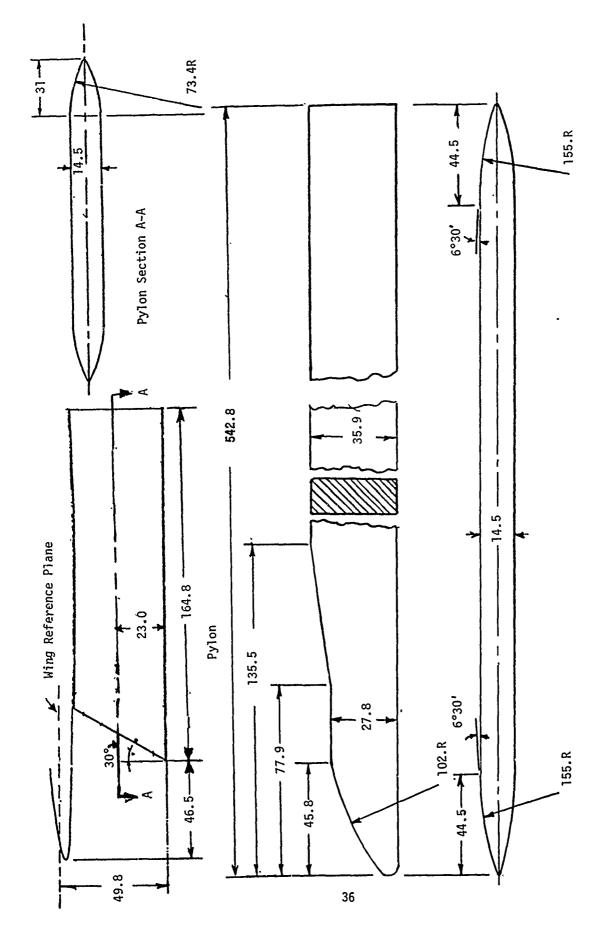


FIGURE 3 MISSILE LAUNCHER AND PYLON DETAILS

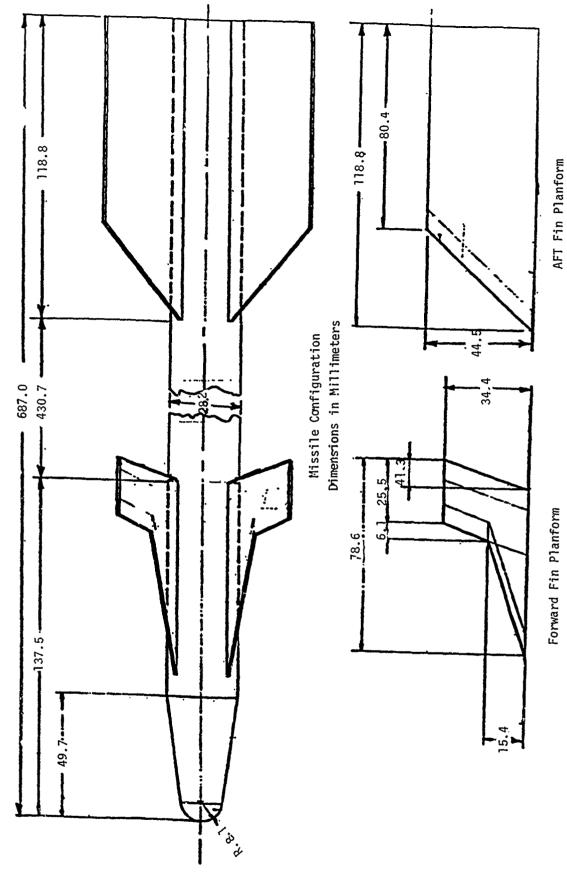


Figure 4 MISSILE DETAILS

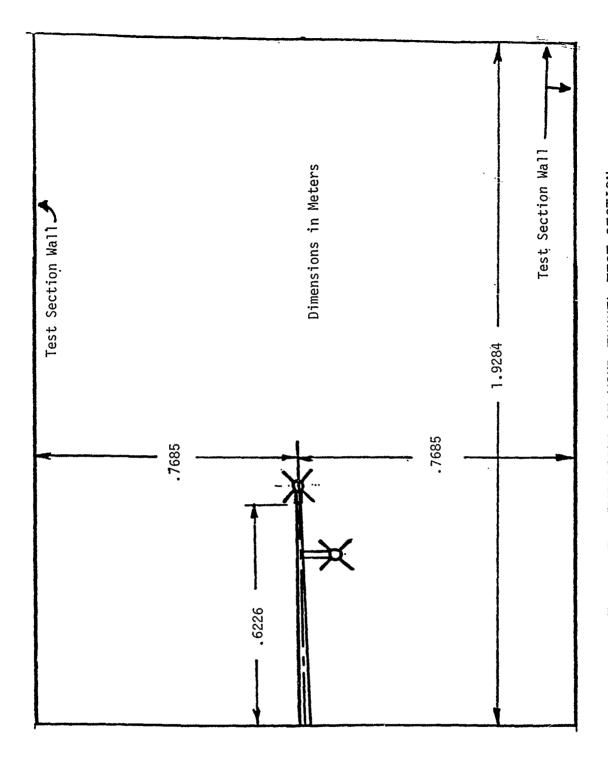
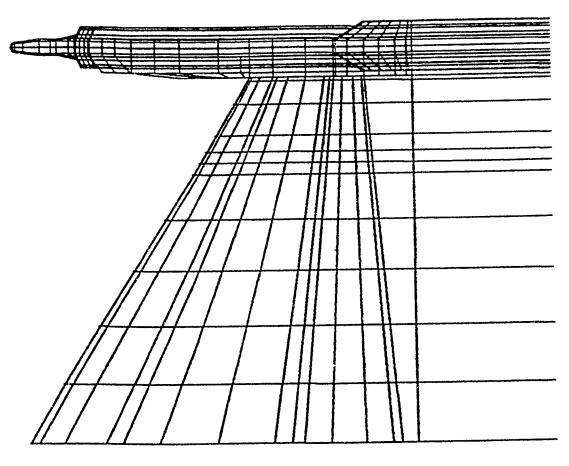


FIGURE 5 DIMENSIONS OF WIND TUNNEL TEST SECTION



PLAN VIEW OF PANELED WING AND TIP MOUNTED MISSILE Figure 6



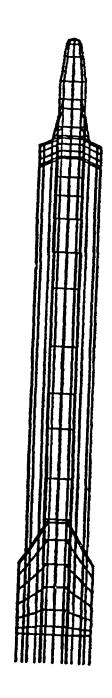
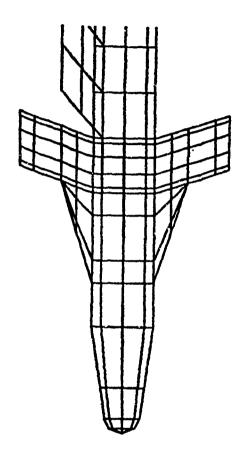


FIGURE 8 SIDE VIEW OF PANELED WING AND TIP MOUNTED MISSILE

FIGURE 9 PLAN VIEW OF PANELED WING AND TIP MOUNTED MISSILE WITHOUT WAKE



FORWARD PORTION OF PANELED MISSILE SHOWING BODY SECTION Figure 11

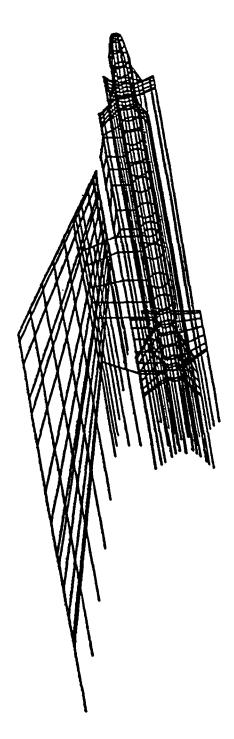


FIGURE 12 PANELED WING AND MISSILE ON PYLON

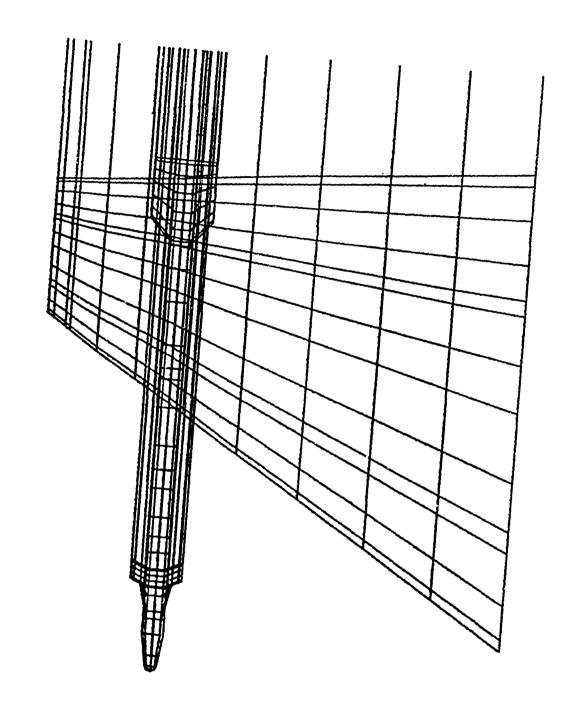


FIGURE 13 PLAN VIEW OF PANELED WING AND MISSILE ON PYLON

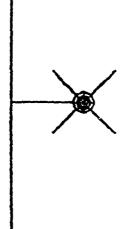
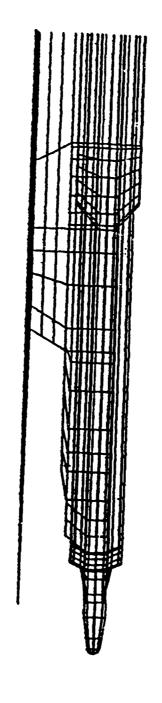


FIGURE 14 FRONT VIEW OF PANELED WING AND MISSILE ON PYLON



SIDE VIEW OF PANELED WING AND MISSILE ON PYLON Figure 15

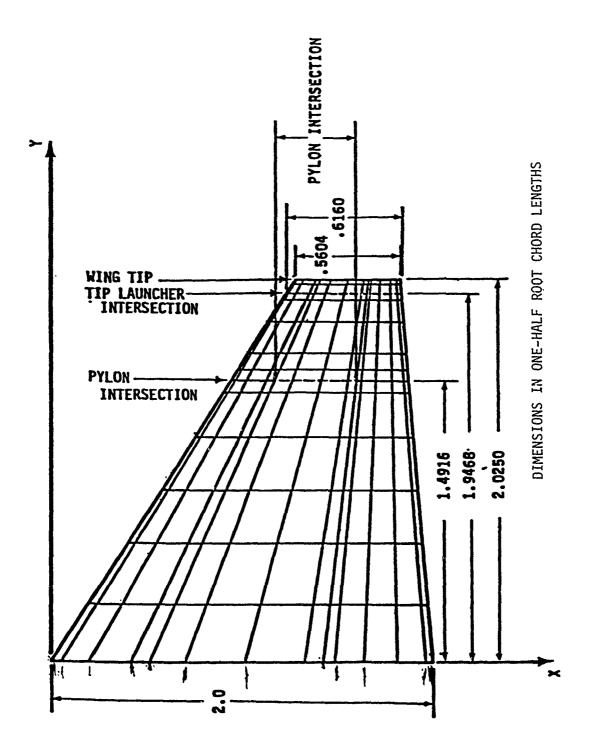
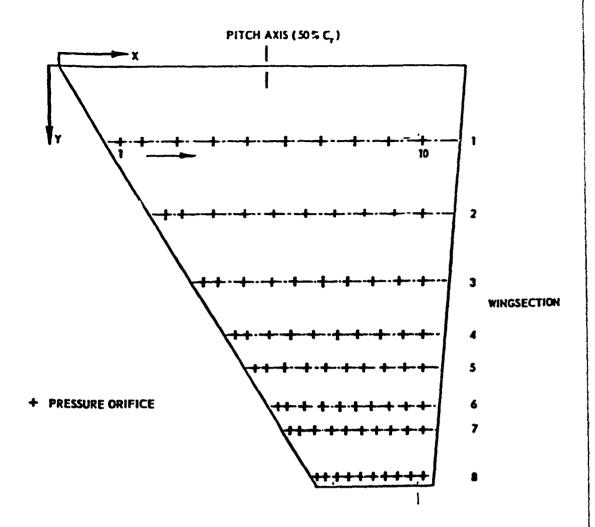


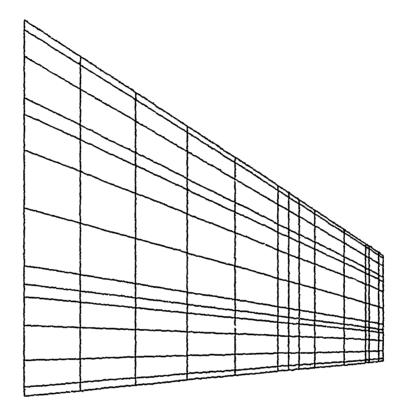
FIGURE 16 PANELING OF THE WING PLANFORM

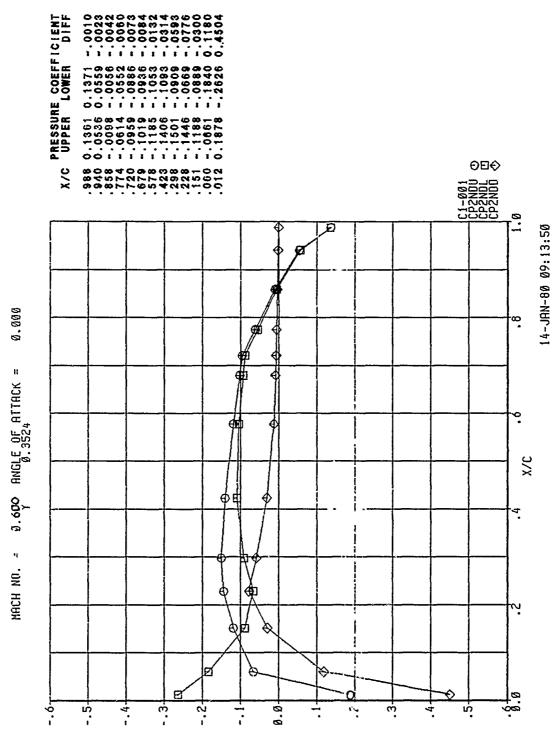


PRESSURE ORIFICES									
SECTION	% SPAN	ORIFICE NUMBER	% CHORD						
1	18.1	1	3						
2	35.5	2	10						
3	51.2	3	20						
4	44.1	4	30						
5	72.1	5	40						
6	81.7	6	50						
7	87.5	7	60						
	97.7		70						
1	1	,	80						
[1	10	90						

SPAN = 0.6226 METERS

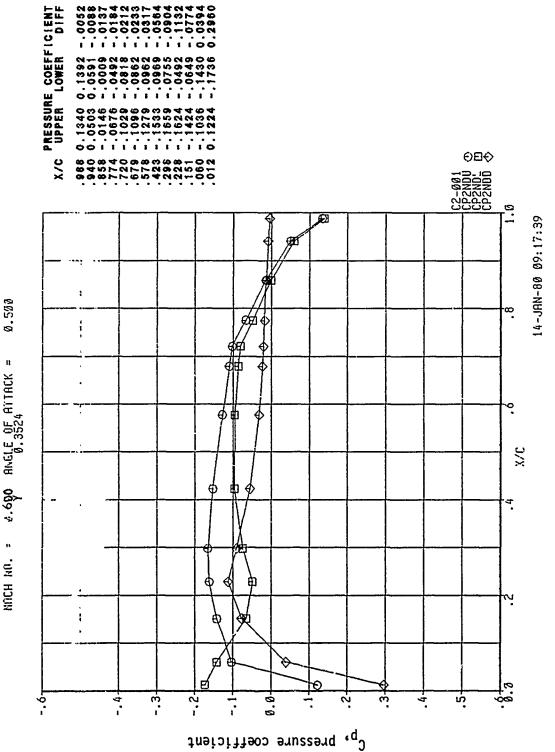
FIGURE 17 LOCATION OF PRESSURE ORIFICES AND TRANDUCERS



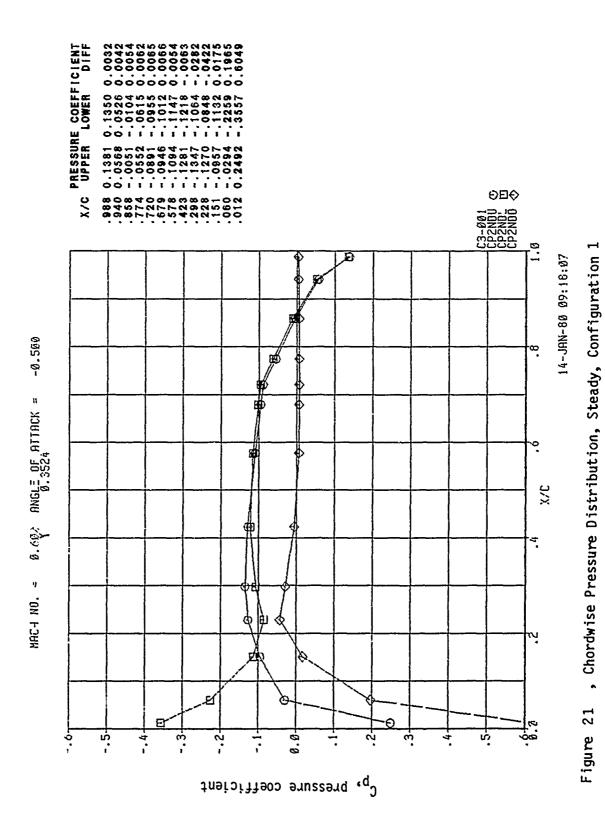


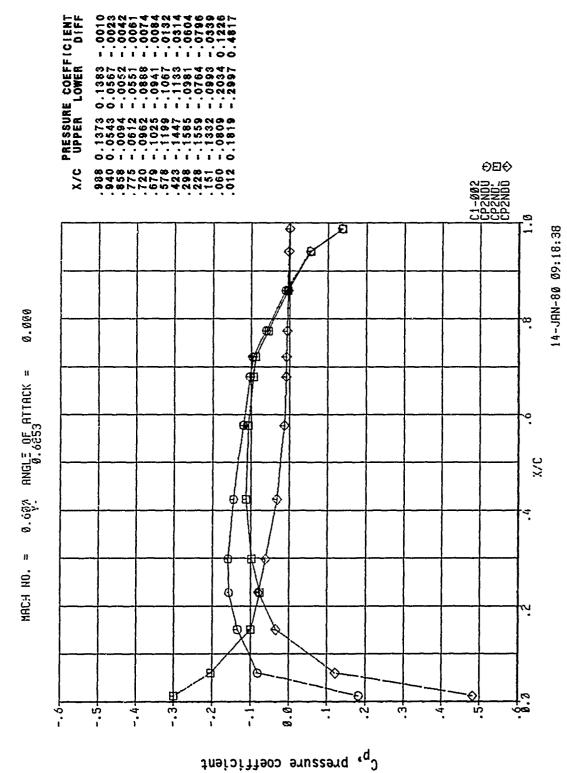
19

tneisiffeos erussarq _{eq}o

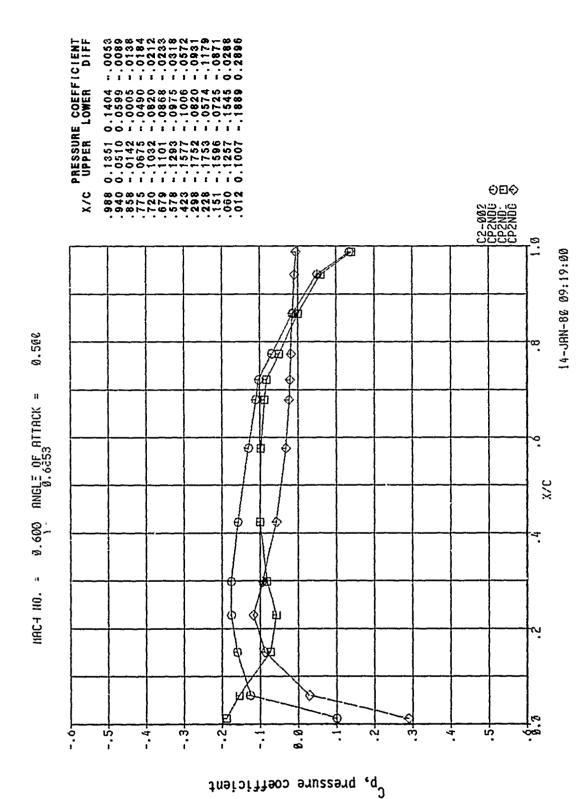


, Chordwise Pressure Distribution, Steady, Configuration Figure 20





, Chordwise Pressure Distribution, Steady, Configuration 22 Figure



, Chordwise Pressure Distribution, Steady, Configuration 1 Figure 23

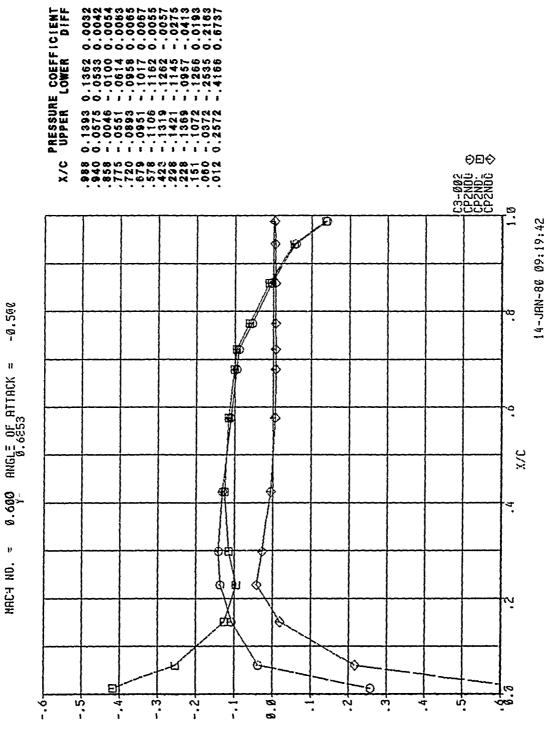
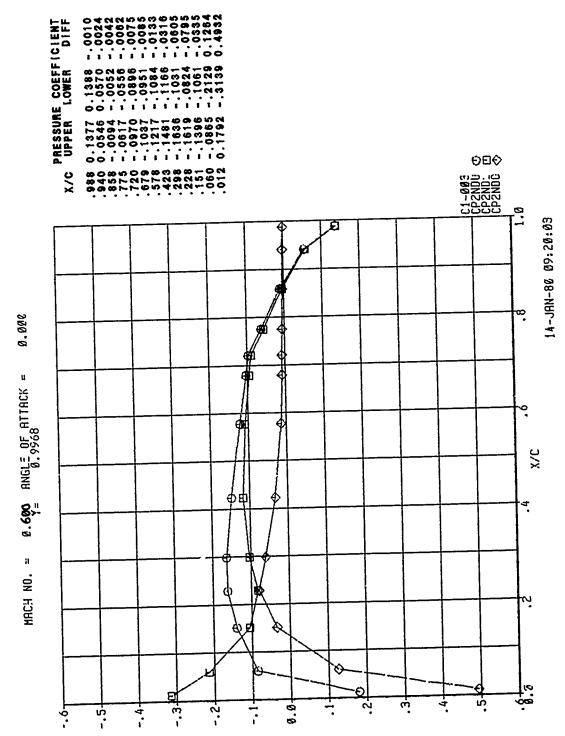


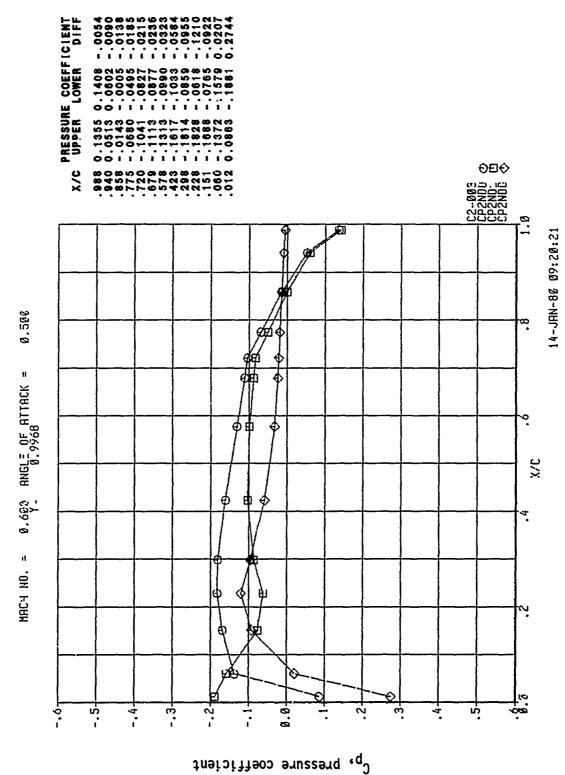
Figure 24

Cp, pressure coefficient

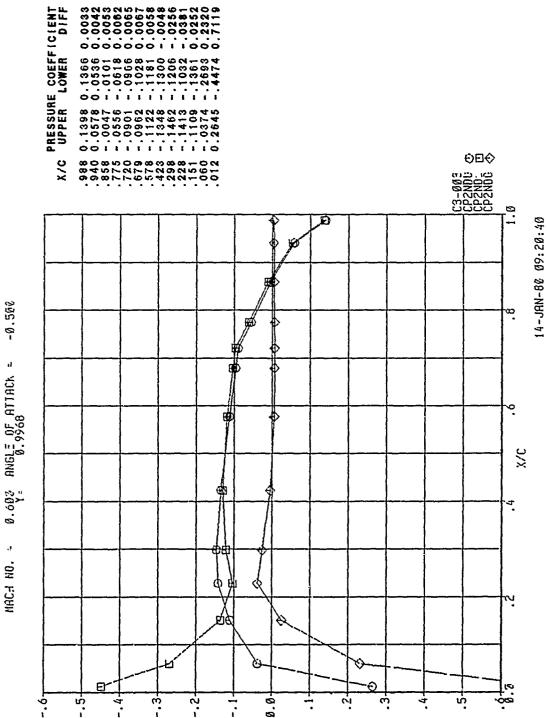


, Chordwise Pressure Distribution, Steady, Configuration Figure 25

Cp, pressure coefficient



, Chordwise Pressure Distribution, Steady, Configuration 1 Figure 26



27

Figure

C_p, pressure coefficient

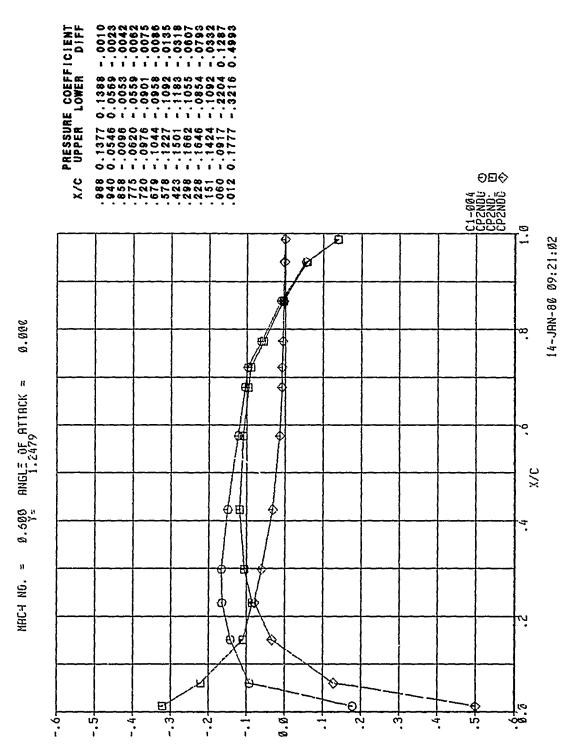
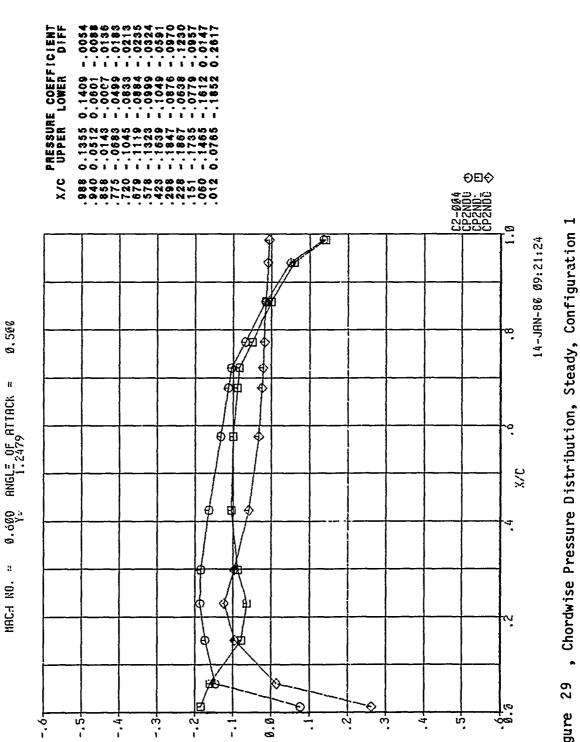
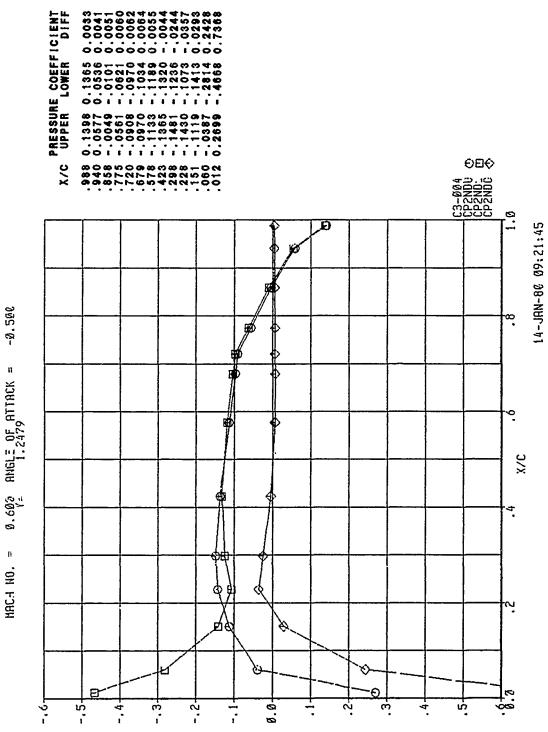


Figure 28

 $C_{\mathbf{p}}$, pressure coefficient



C_p, pre*ss*ure coefficient



 $c_{
m p}$, pressure coefficient

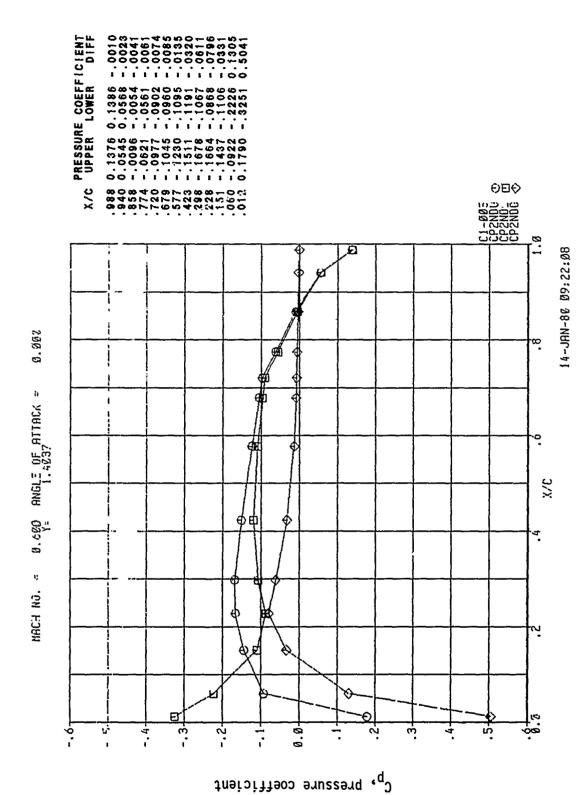
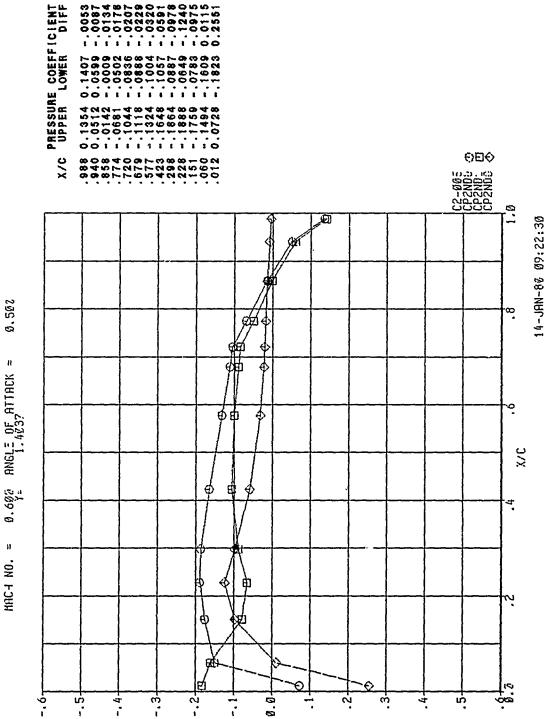


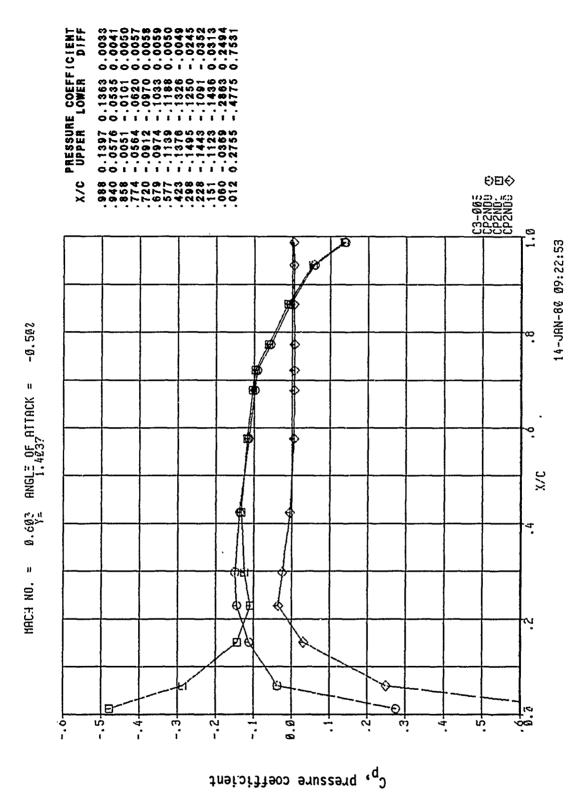
Figure 31 , Chordwise Pressure Distribution, Steady, Configuration



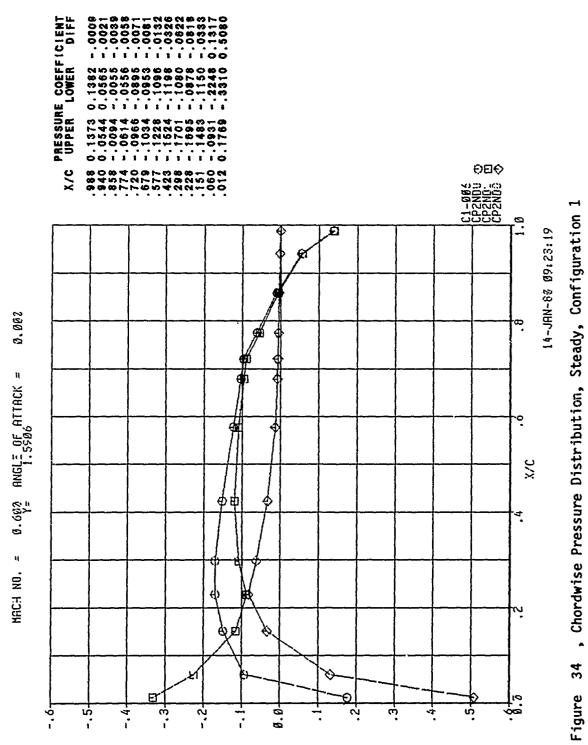
32

 σ_{p} , pressure coefficient

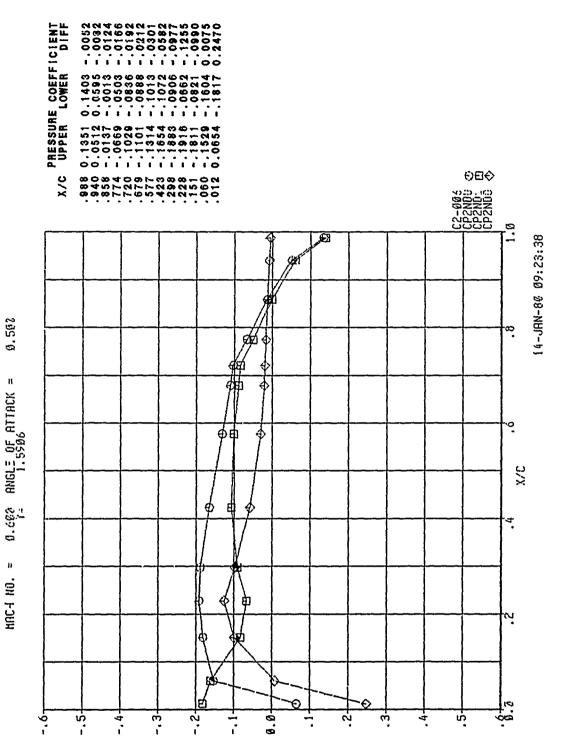
MAC4 NO.



, Chordwise Pressure Distribution, Steady, Configuration 1 33 Figure

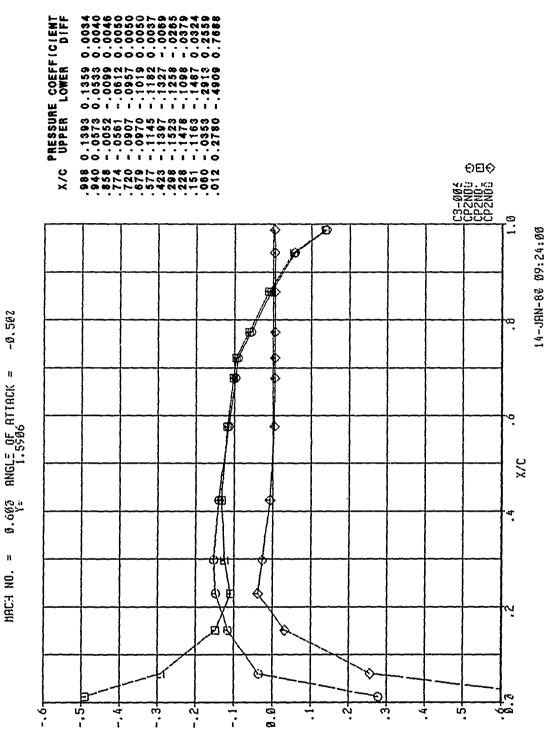


C_p, pressure coefficient

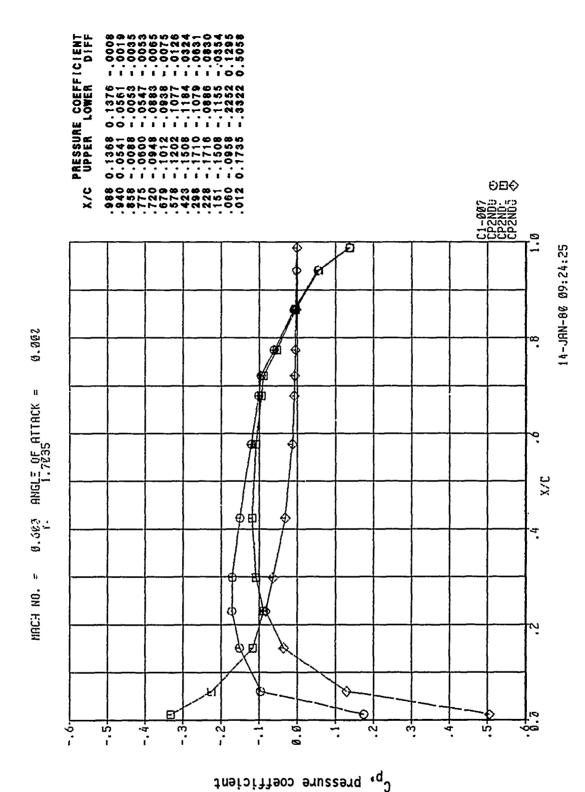


ure 35 , Chordwise Pressure Distribution, Steady, Configuration

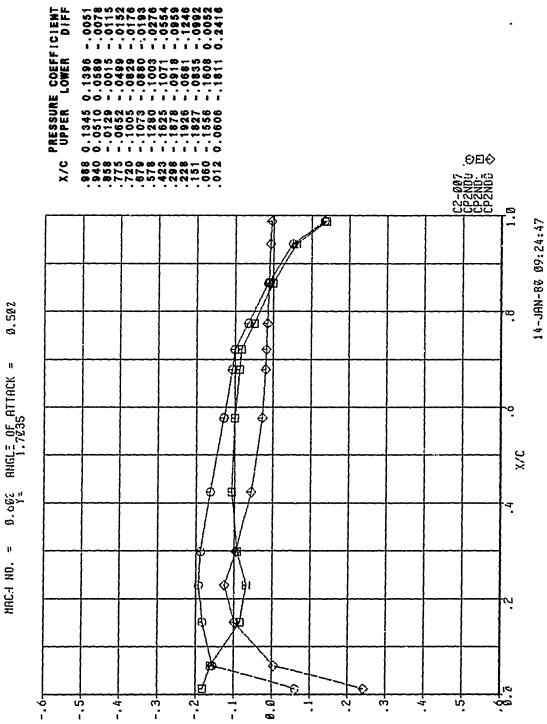
 $C_{\mathbf{p}}$, pressure coefficient



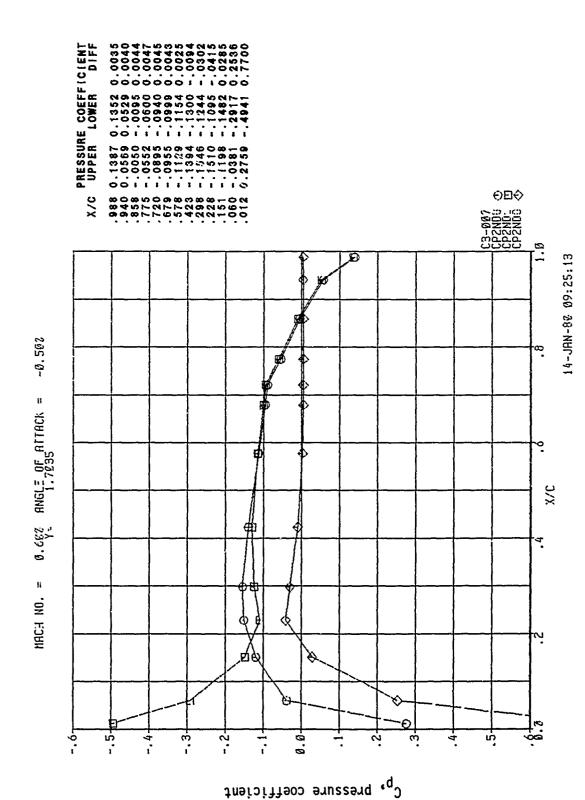
C_p, pressure coefficient



, Chordwise Pressure Distribution, Steady, Configuration 1 Figure 37



 c_{p} , pressure coefficient



gure 39 , Chordwise Pressure Distribution, Steady, Configuration

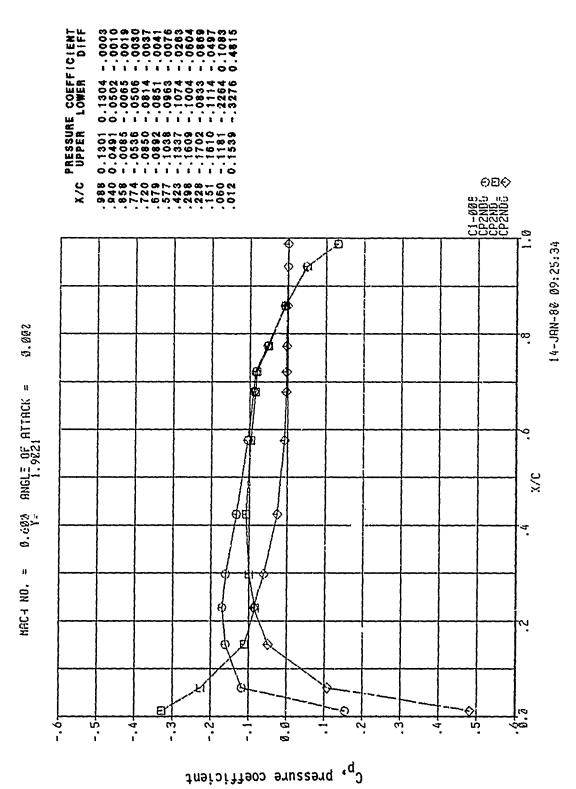
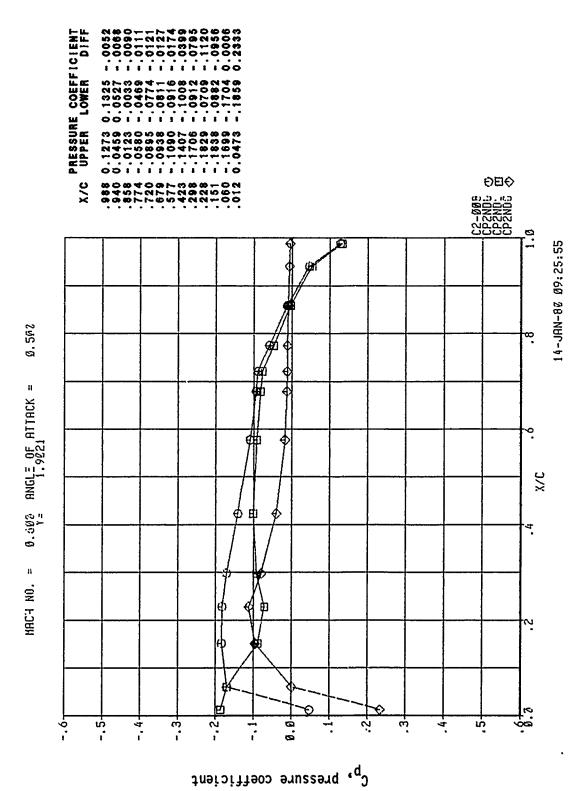
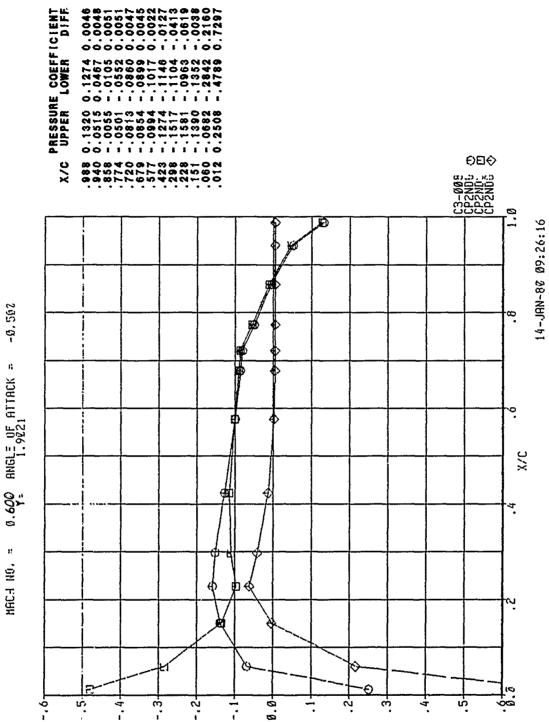


Figure 40 , Chordwise Pressure Distribution, Steady, Configuration

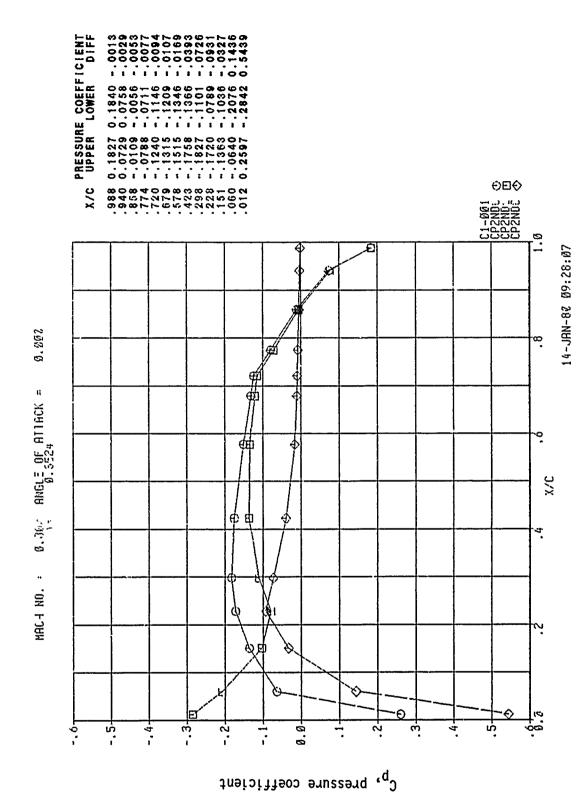


Chordwise Pressure Distribution, Steady, Configuration 1 4.1 Figure

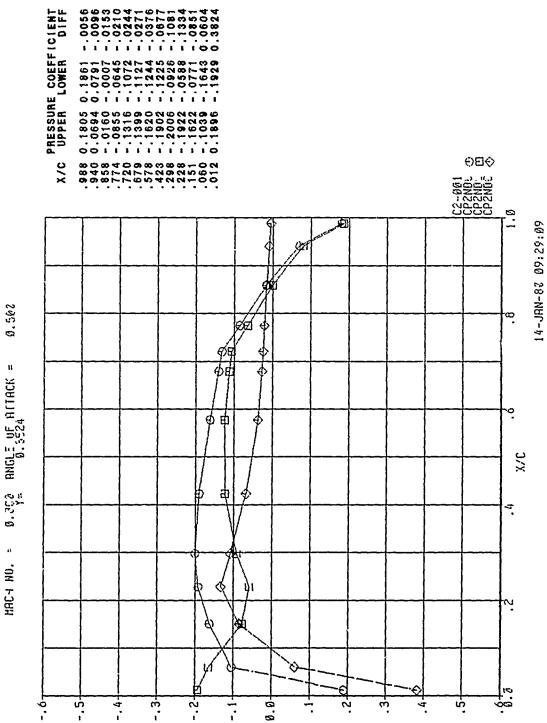


42

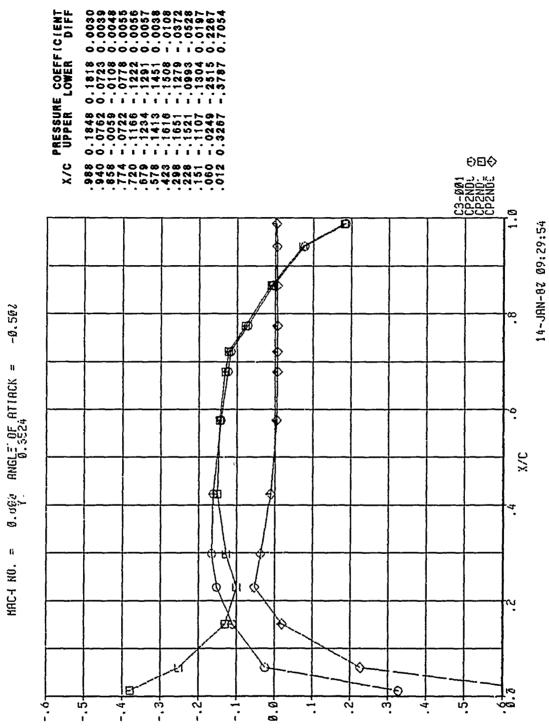
C_p, pressure coefficient



, Chordwise Pressure Distribution, Steady, Configuration Figure 43

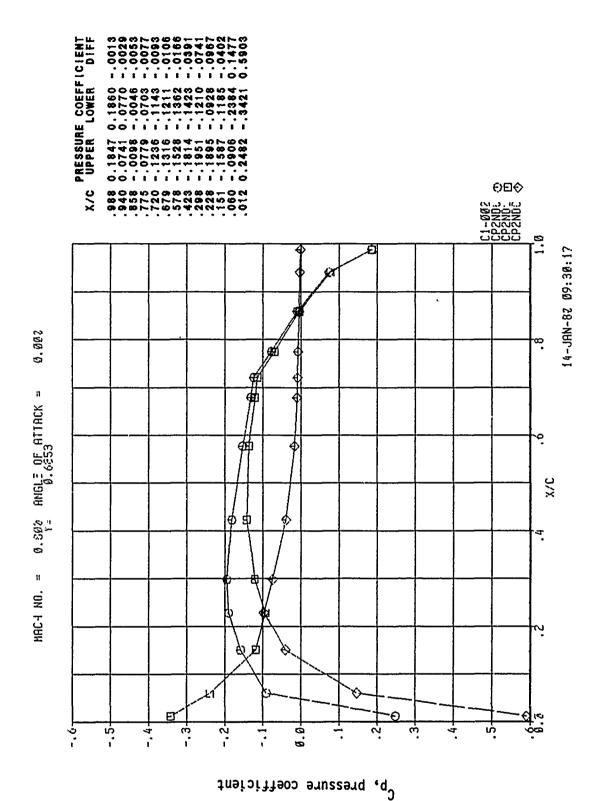


 $C_{\mathbf{p}}$, pressure coefficient

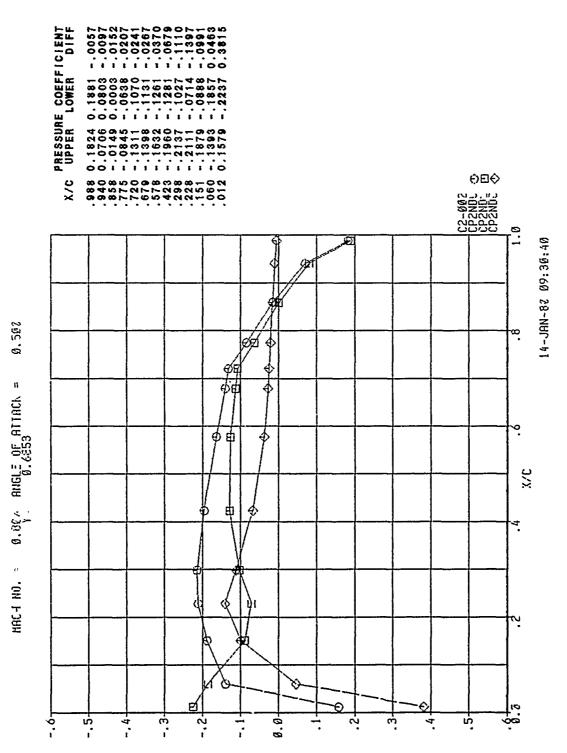


45

 $c_{
m p}$, pressure coefficient

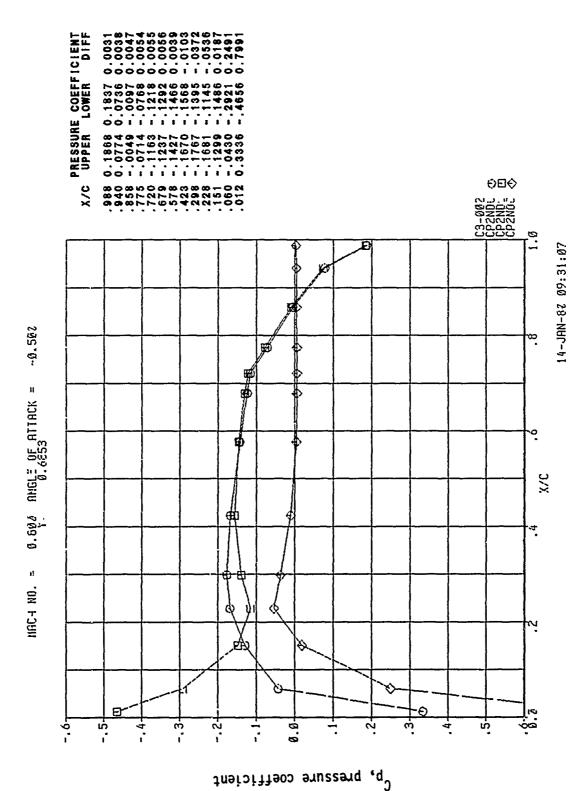


, CAGrdwise Pressure Distribution, Steady, Configuration 1 Figure 46

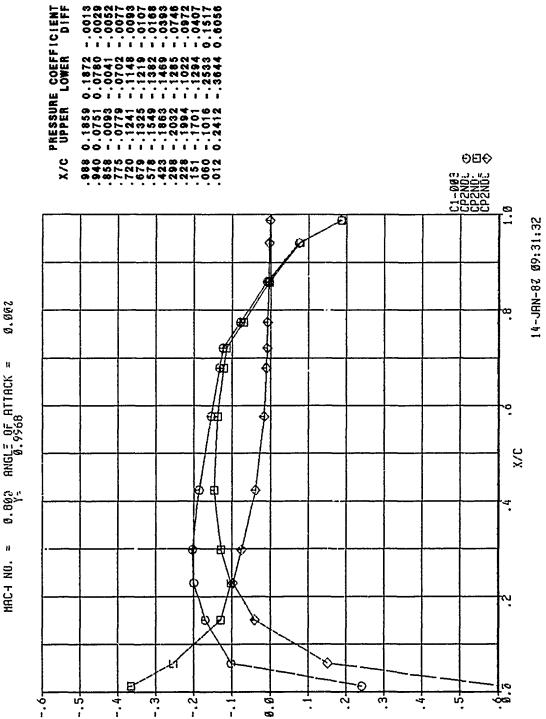


, Chordwise Pressure Distribution, Steady, Configuration 1 47 Figure

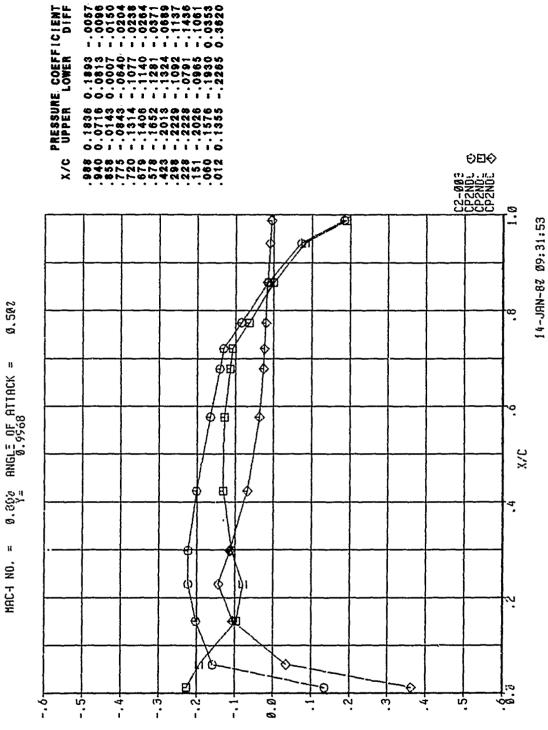
Cp, pressure coefficient



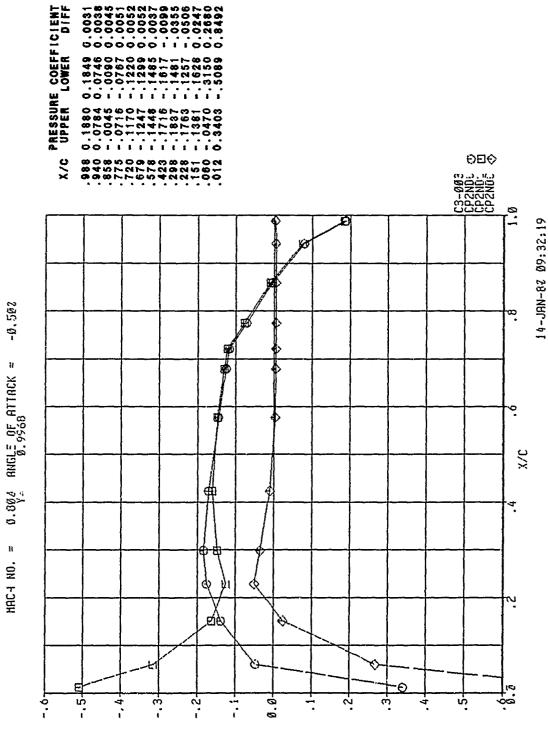
, Chordwise Pressure Distribution, Steady, Configuration 1 48 Figure



 $\textbf{C}_{\textbf{p}}$ pressure coefficient

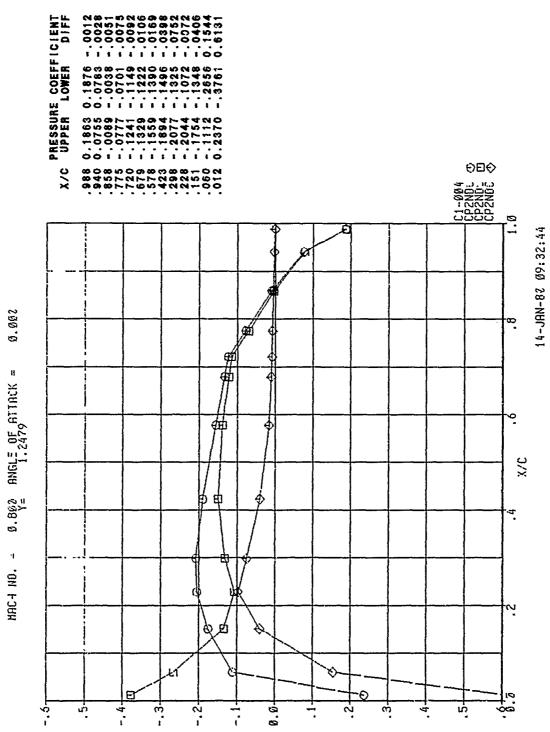


 $\sigma_{
m p}$, pressure coefficient

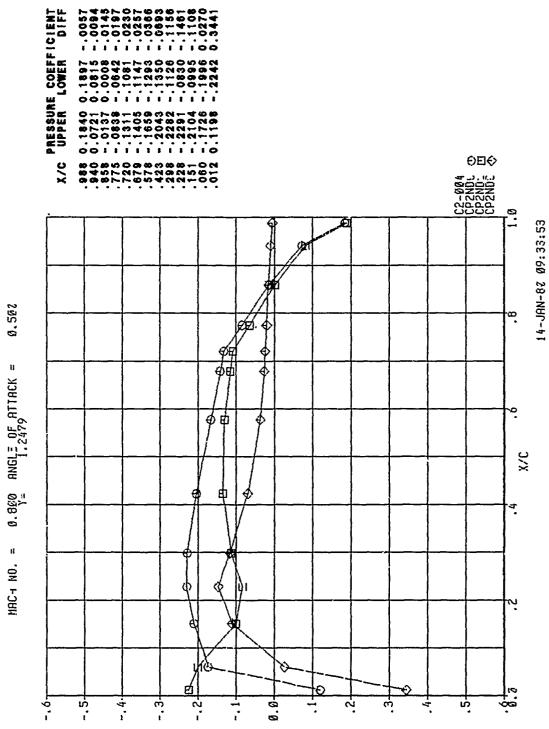


51

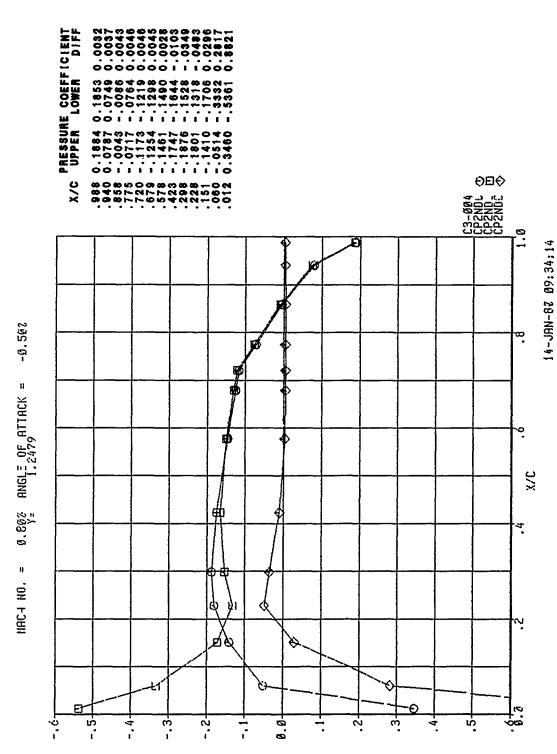
Cp, pressure coefficient



 $c_{\rm p}$, pressure coefficient

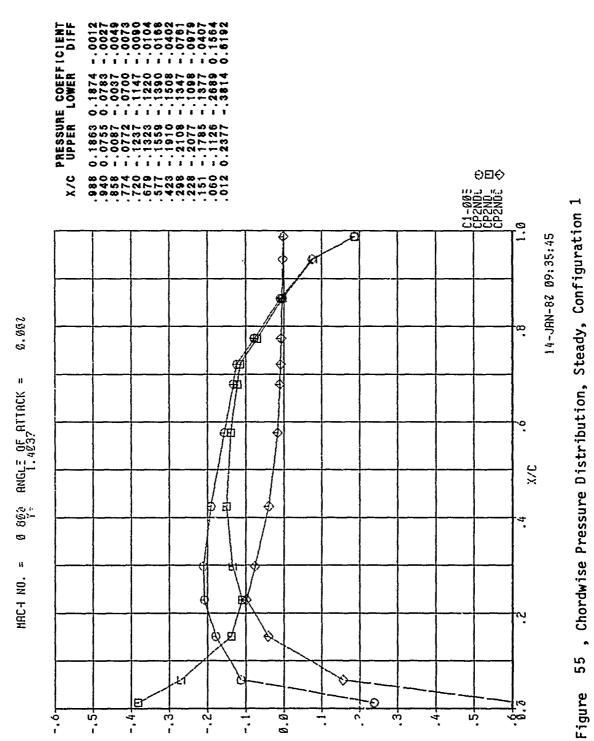


 σ_{p_ℓ} pressure coefficient



54

 $c_{
m p}$, pressure coefficient



 $C_{\mathbf{p}}$, pressure coefficient

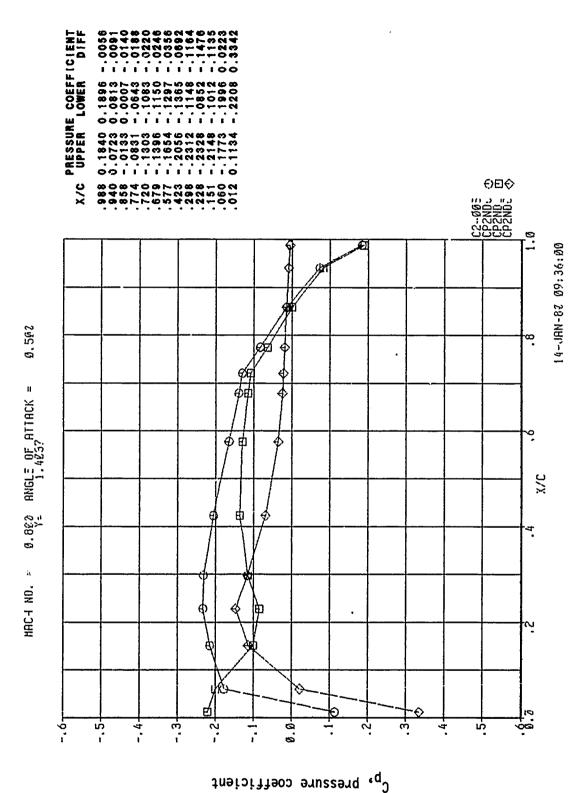


Figure 56 , Chordwise Pressure Distribution, Steady, Configuration

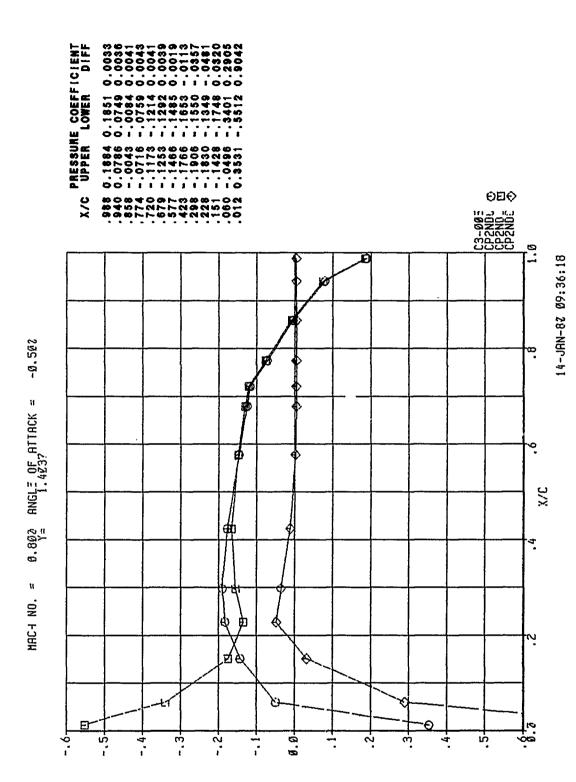
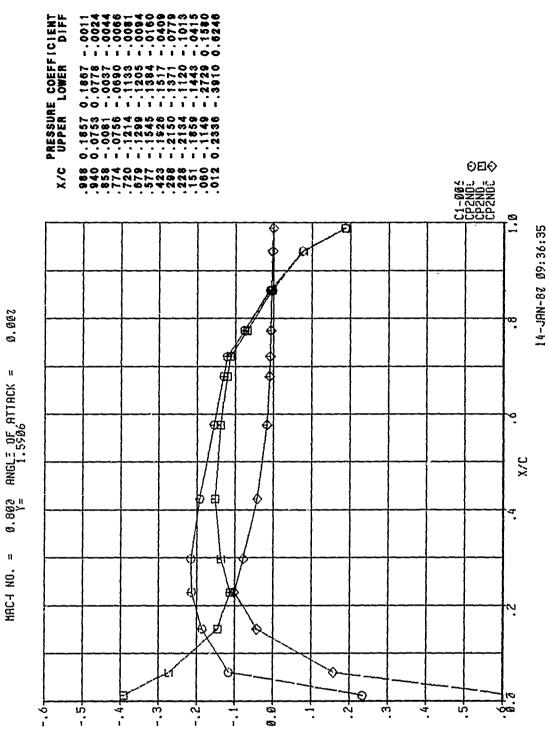
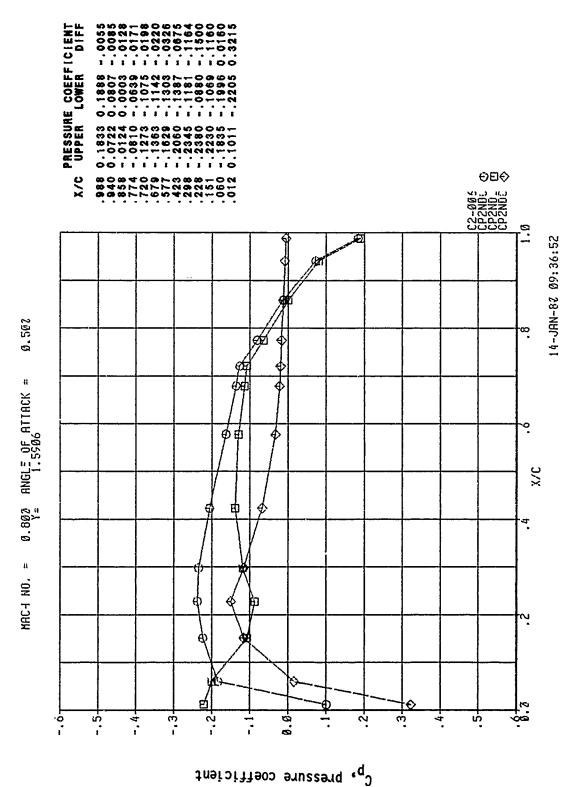


Figure 57 , Chordwise Pressure Distribution, Steady, Configuration

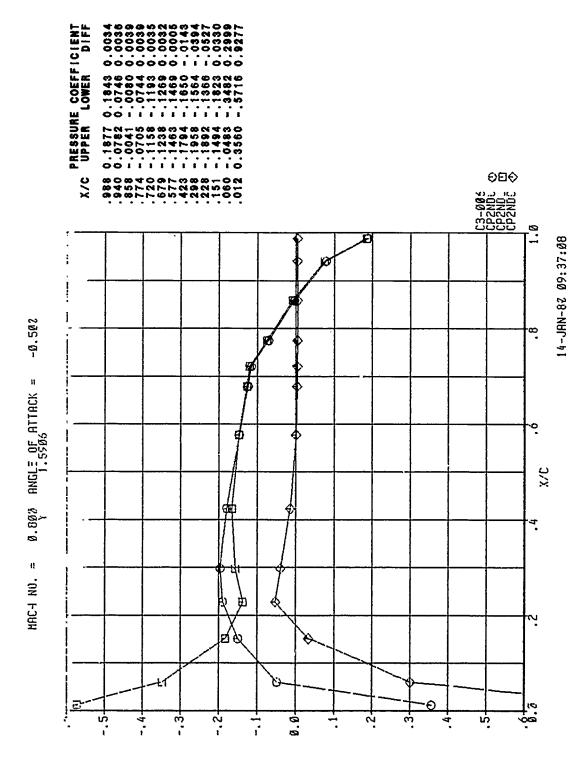
 $\sigma_{\rm p}$, pressure coefficient



C_p, pressure coefficient



Figure



60, Chordwise Pressure Distribution, Steady, Configuration 1 Figure

بسدسيد يستن

47

 C_{p} , pressure coefficient

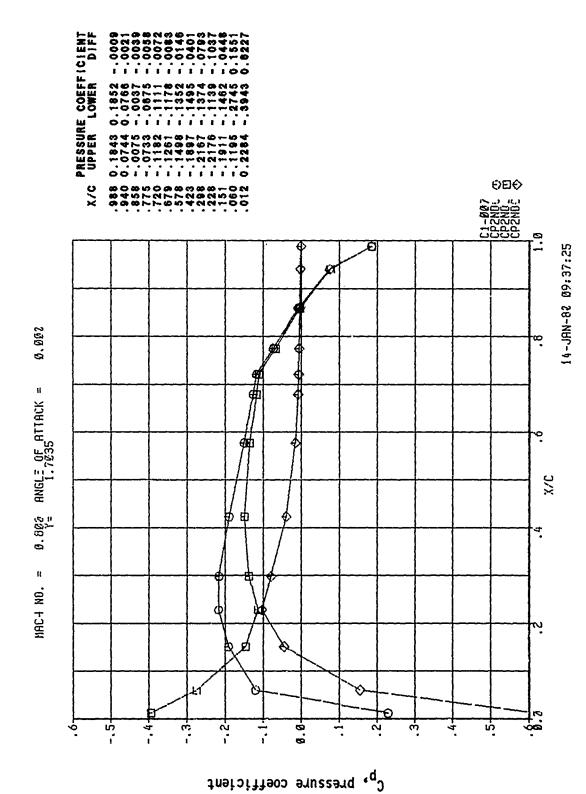
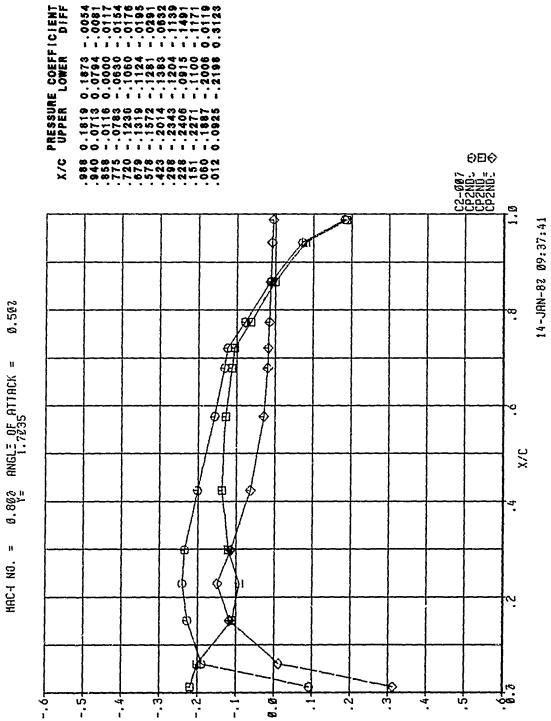
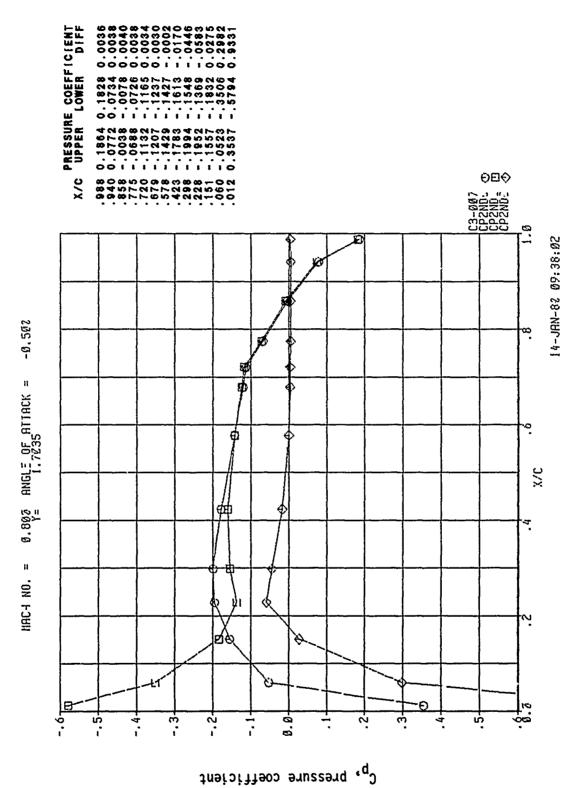


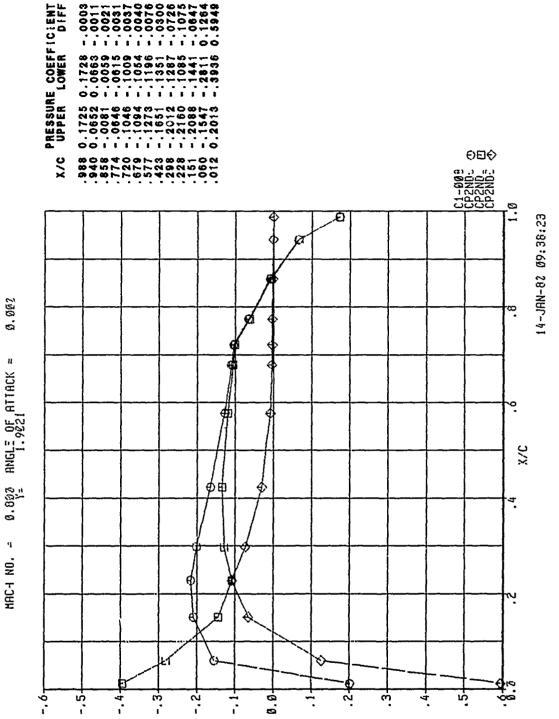
Figure 61, Chordwise Pressure Distribution, Steady, Configuration 1



C_p, pressure coefficient



, Chordwise Pressure Distribution, Steady, Configuration 1 63 Figure



C_p, pressure coefficient

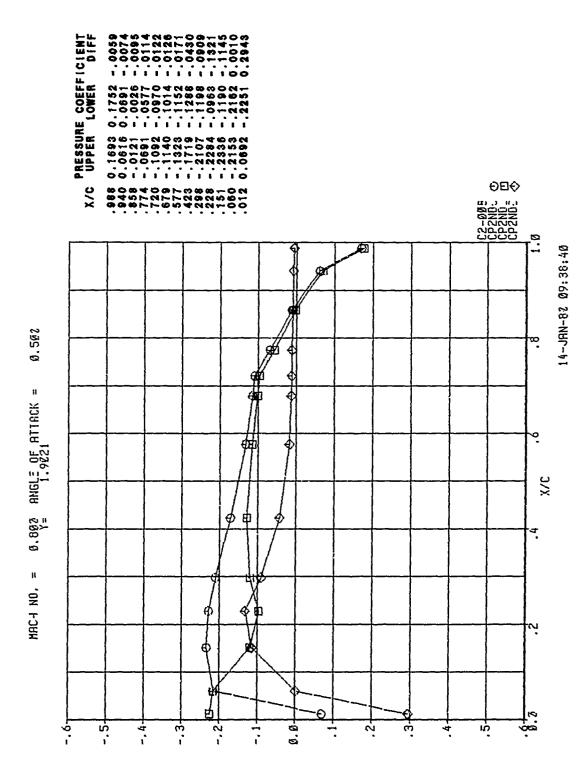
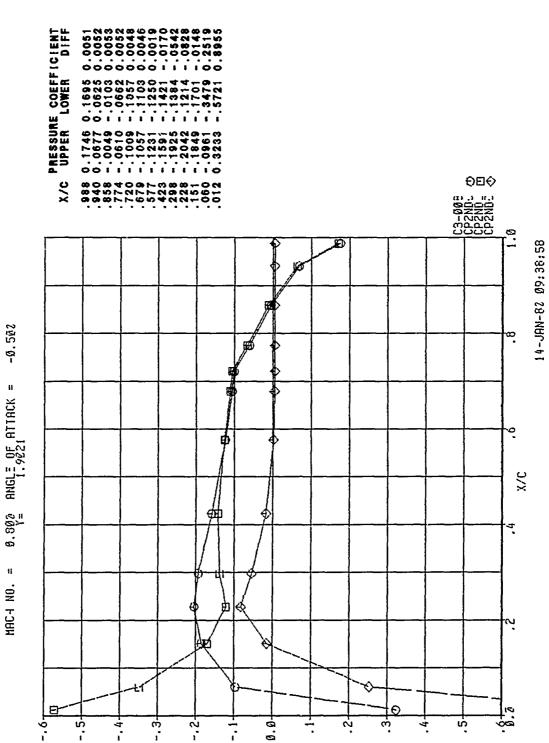
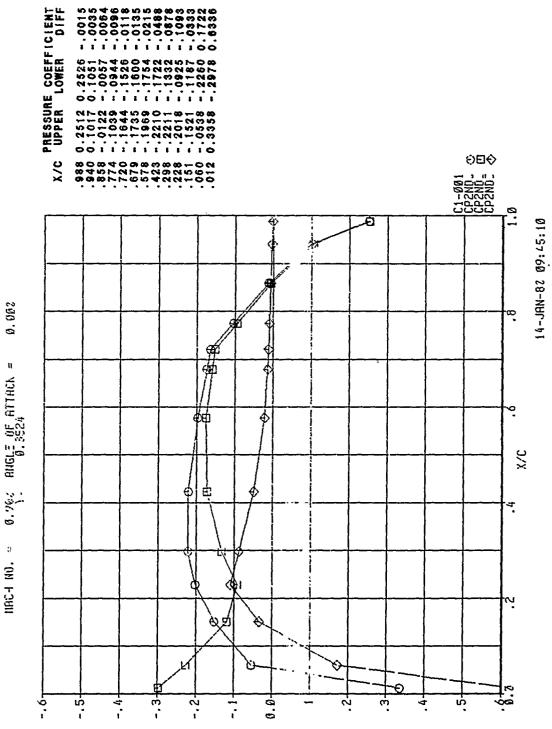


Figure 65, Chordwise Pressure Distribution, Steady, Configuration

 $C_{\mathbf{p}^*}$ pressure coefficient



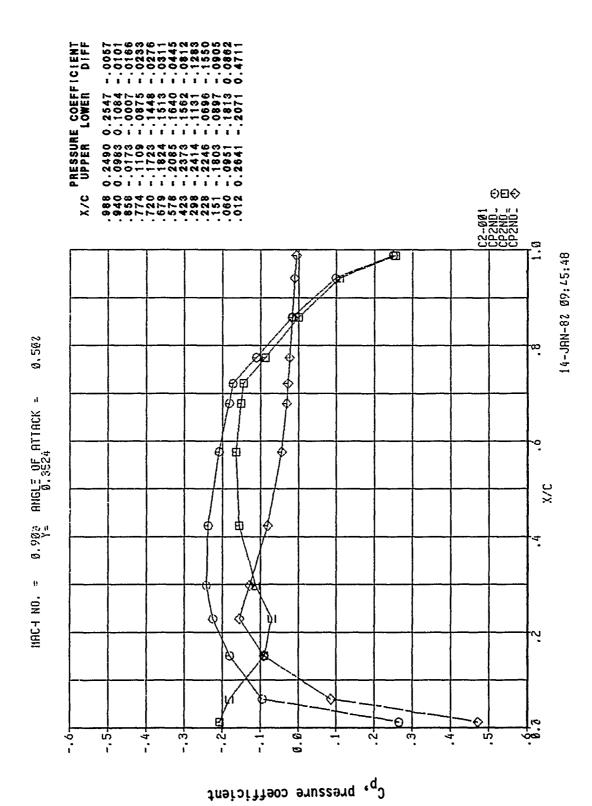
 $c_{
m p}$, pressure coefficient



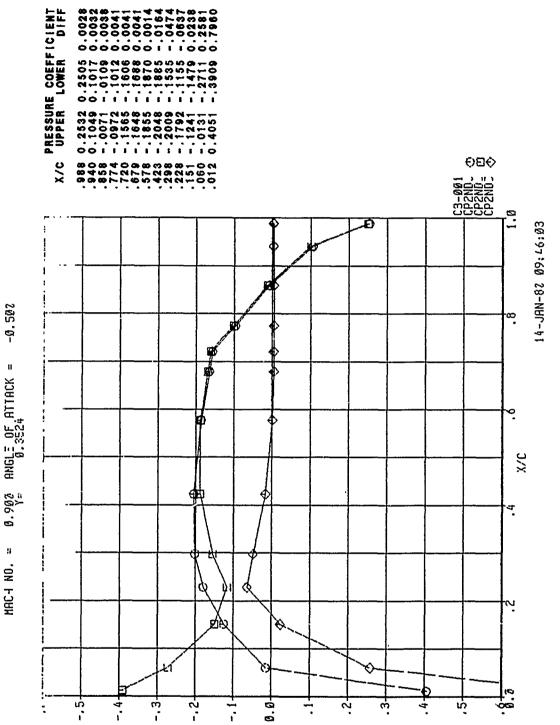
Figure

1

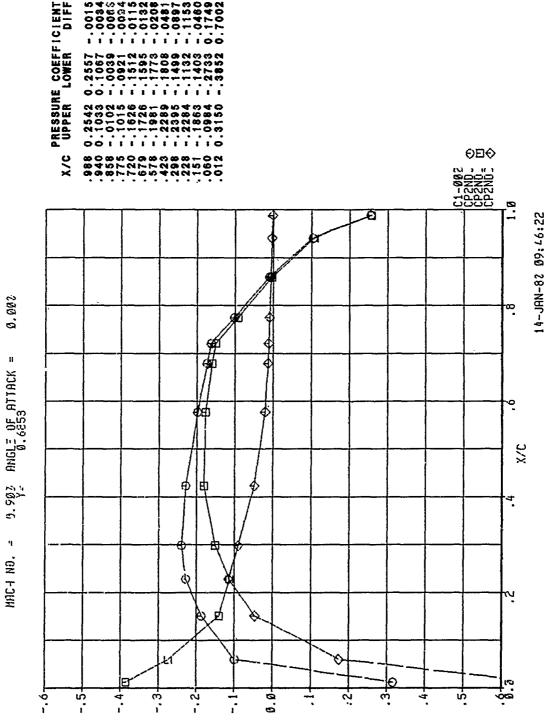
 $c_{
m p}$, pressure coefficient



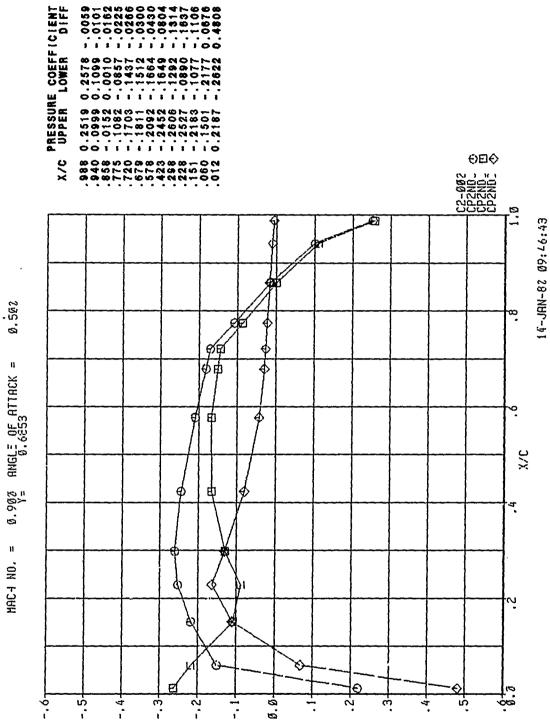
ure 68, Chordwise Pressure Distribution, Steady, Configuration 1



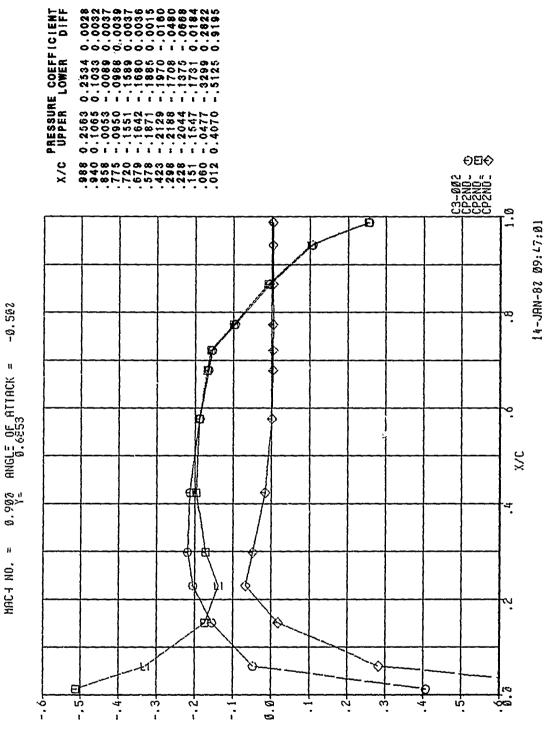
 $c_{
m p}$, pressure coefficient



the pressure coefficient q^{J}



 $c_{
m p}$, pressure coefficient



72, Chordwise Pressure Distribution, Steady, Configuration

 $C_{\mathbf{p}}$, pressure coefficient

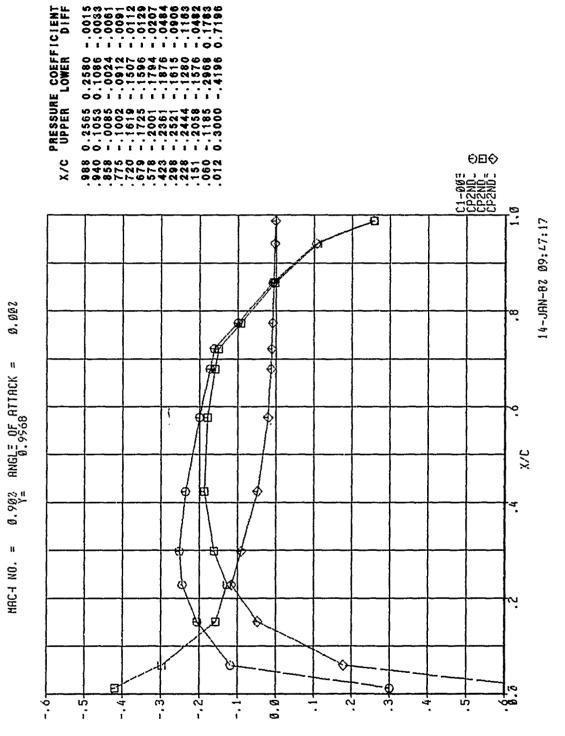
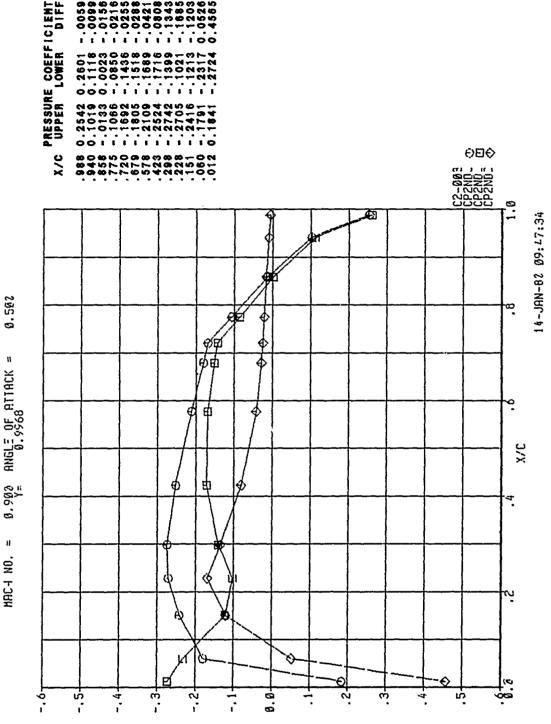


Figure 73, Chordwise Pressure Distribution, Steady, Configuration 1

 $C_{\mathbf{p}}$, pressure coefficient



C_p, pressure coefficient

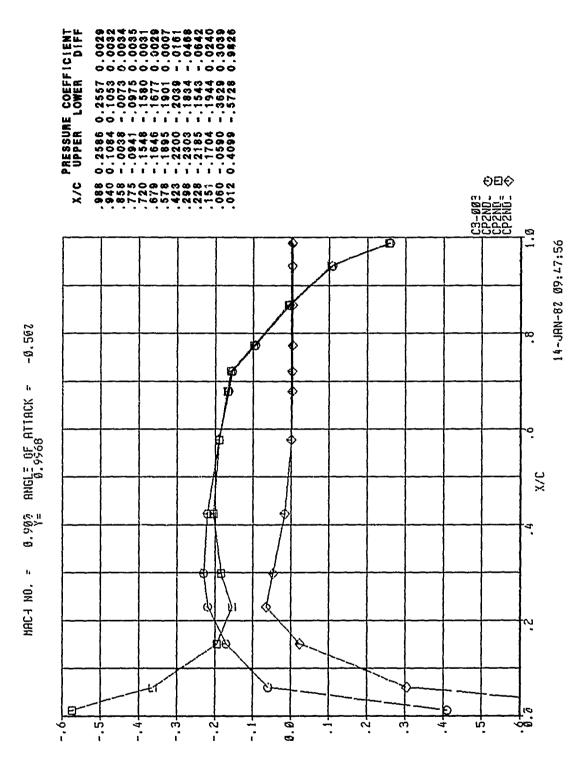
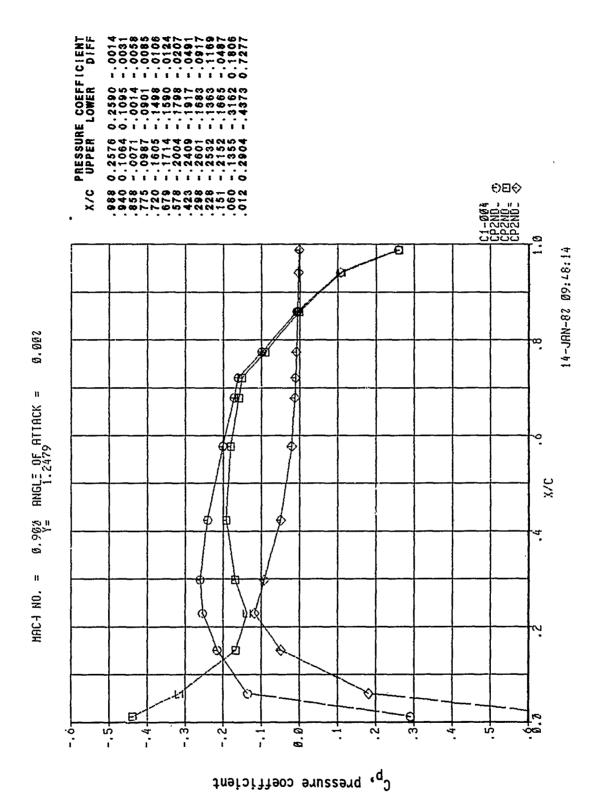
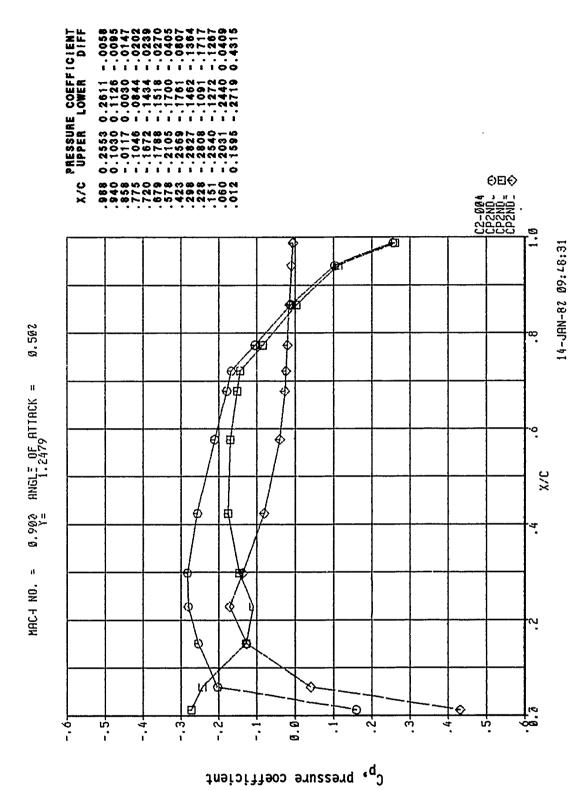


Figure 75, Chordwise Pressure Distribution, Steady, Configuration 1

 C_{p} , pressure coefficient



e 76 , Chordwise Pressure Distribution, Steady, Configuration



77, Chordwise Pressure Distribution, Steady, Configuration

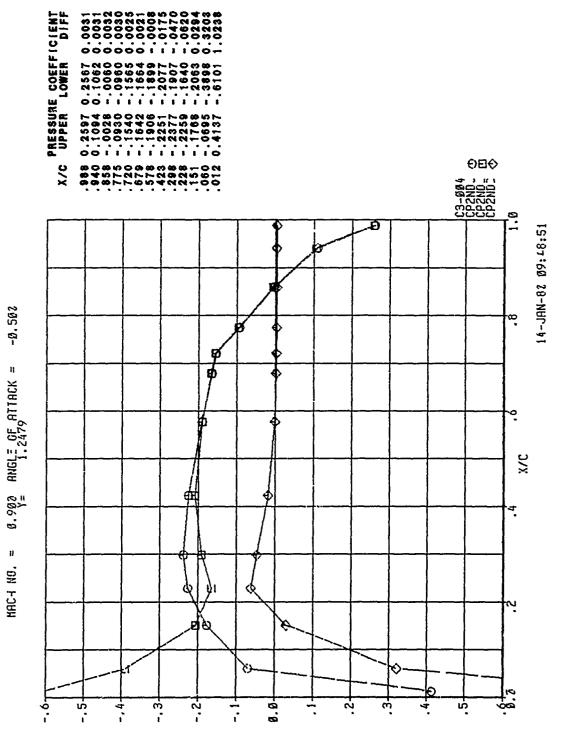
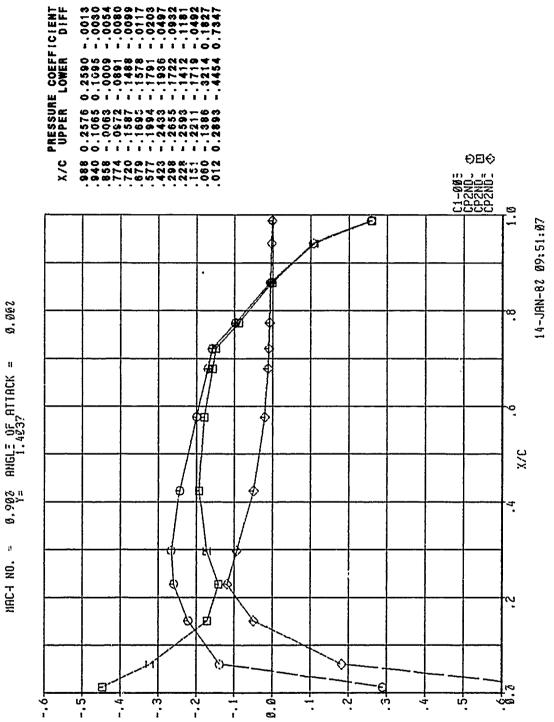
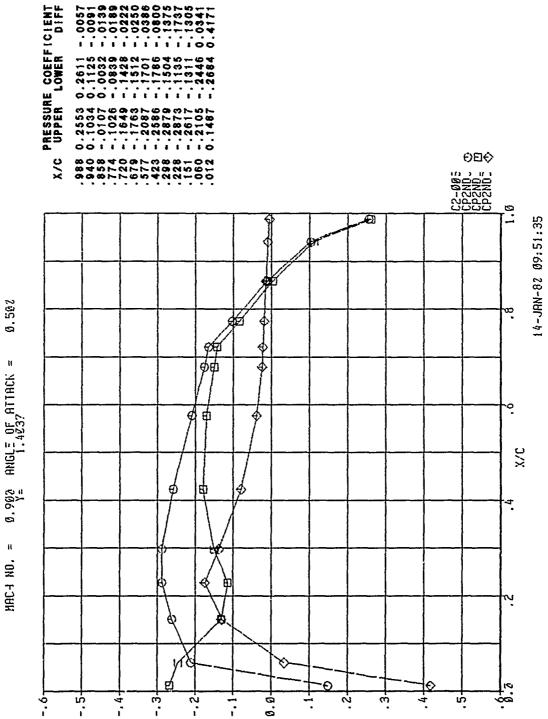


Figure 78, Chordwise Pressure Distribution, Steady, Configuration 1

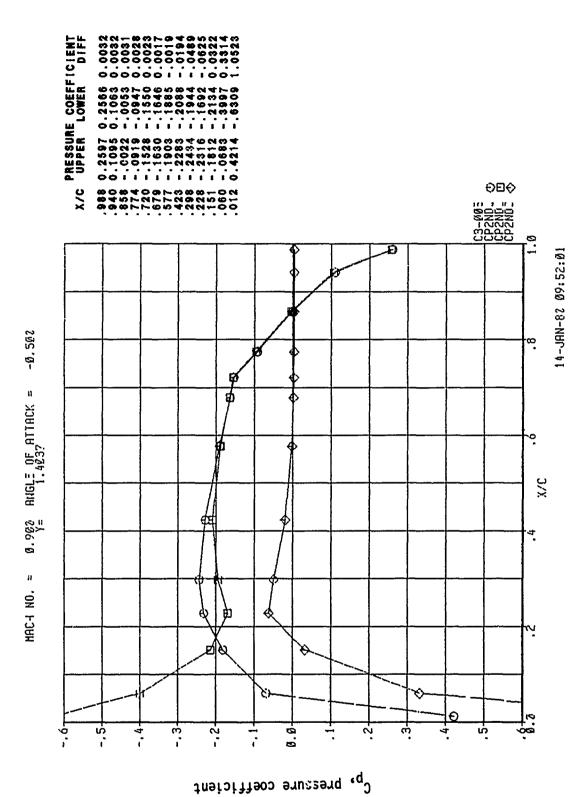
 $C_{\mathbf{p}}$, pressure coefficient



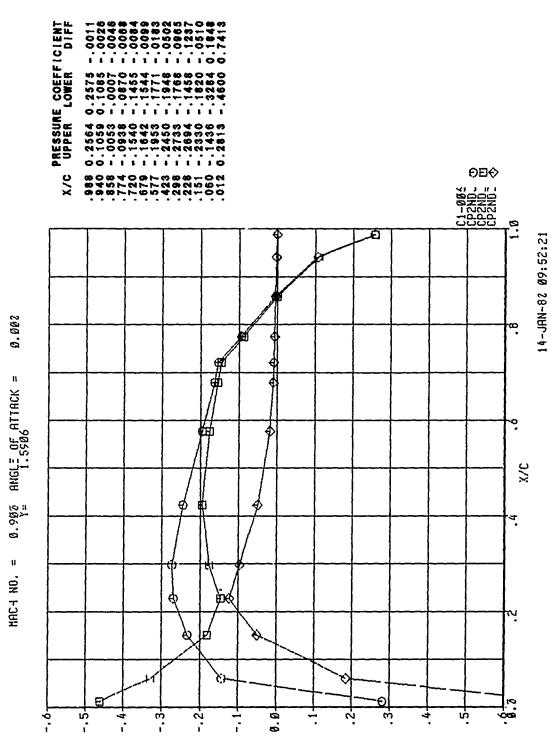
Up, pressure coefficient (g)



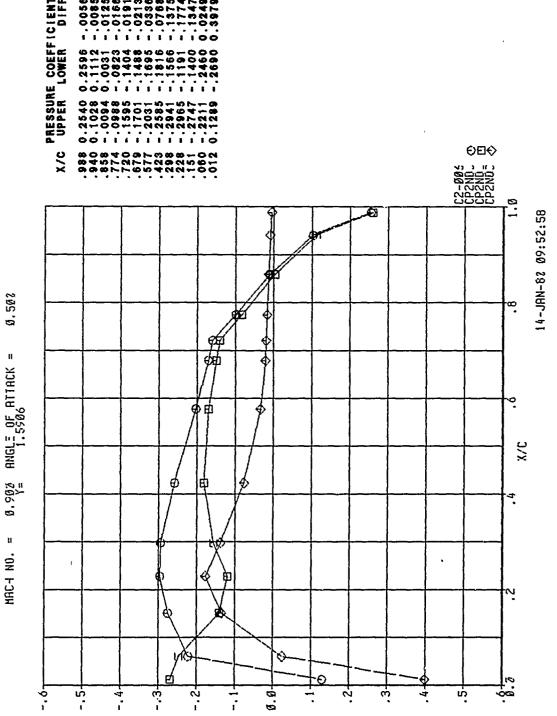
C_p, pressure coefficient



81, Chordwise Pressure Distribution, Steady, Configuration 1 Figure

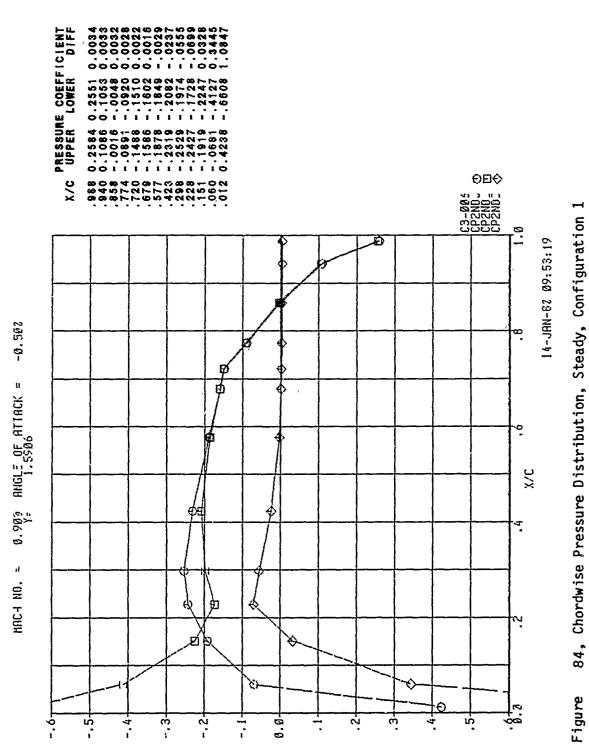


C_p, pressure coefficient



ire 83, Chordwise Pressure Distribution, Steady, Configuration I

Cp, pressure coefficient



Cp, pressure coefficient

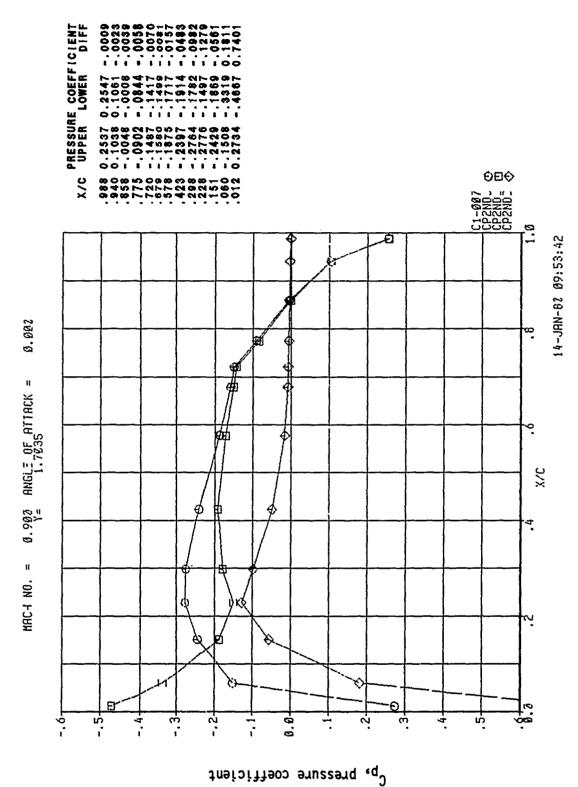
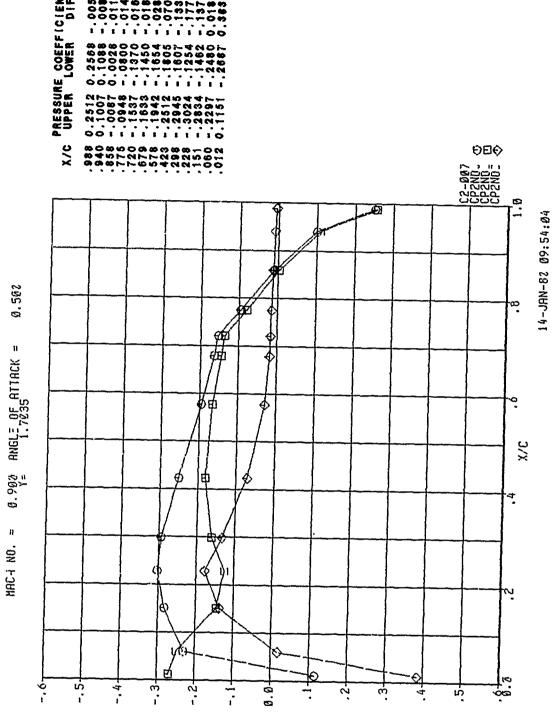
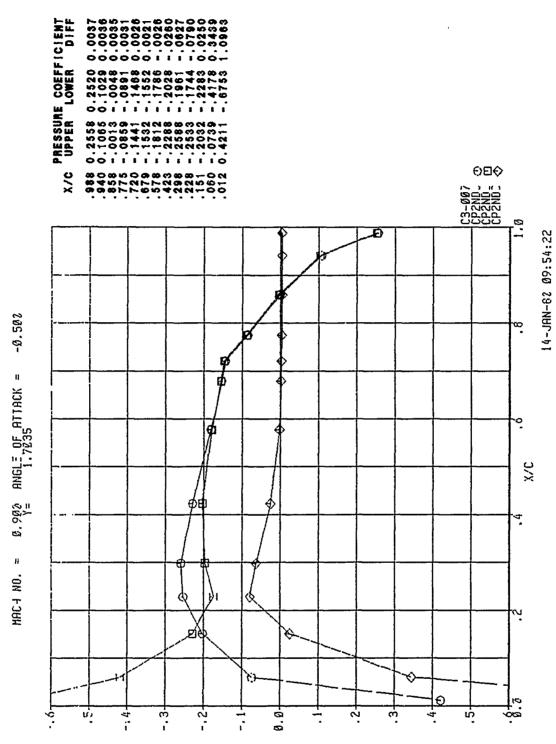


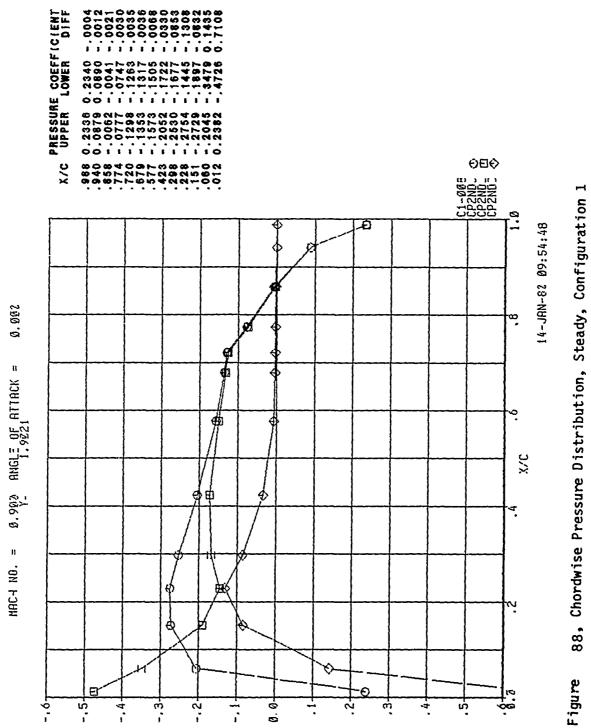
Figure 85, Chordwise Pressure Distribution, Steady, Configuration 1



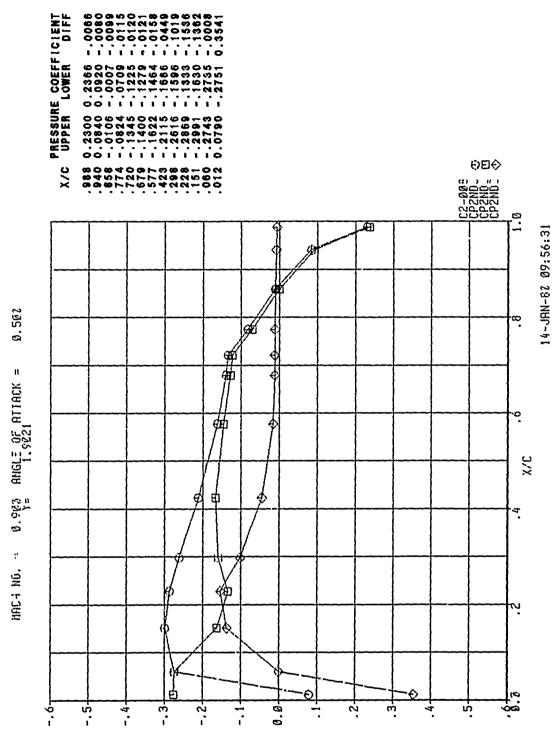
 $C_{\mathbf{p}}$, pressure coefficient



 $C_{\mathbf{p}}$, pressure coefficient



 $\sigma_{\rm p}$ pressure coefficient



 $C_{\rm p}$, pressure coefficient

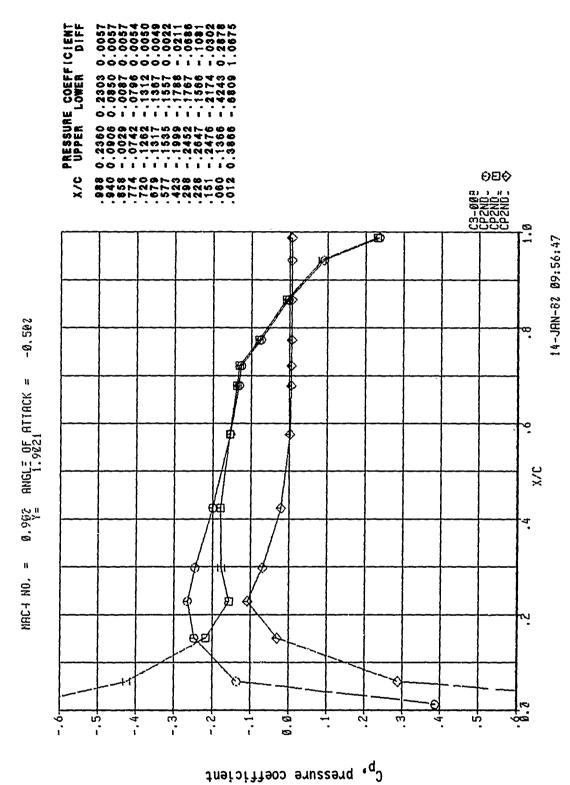
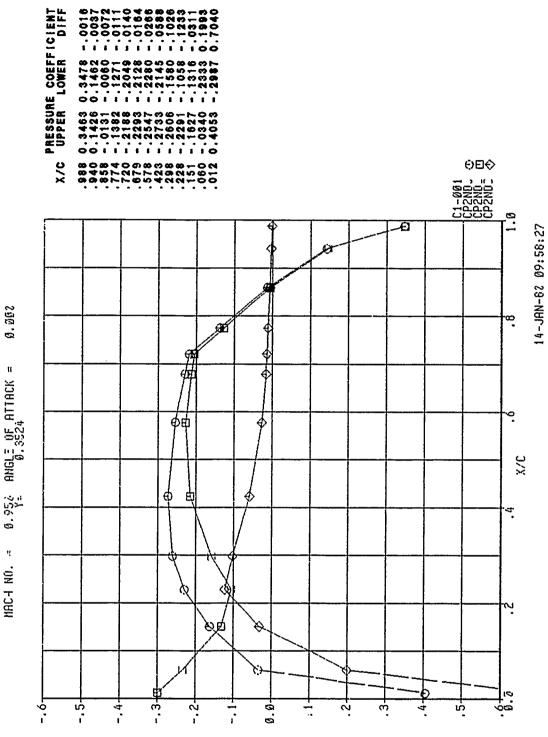
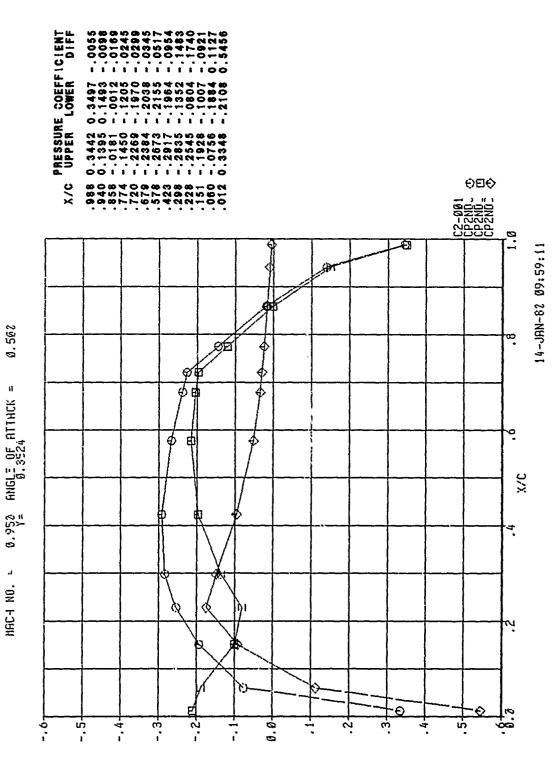


Figure 90, Chordwise Pressure Distribution, Steady, Configuration 1

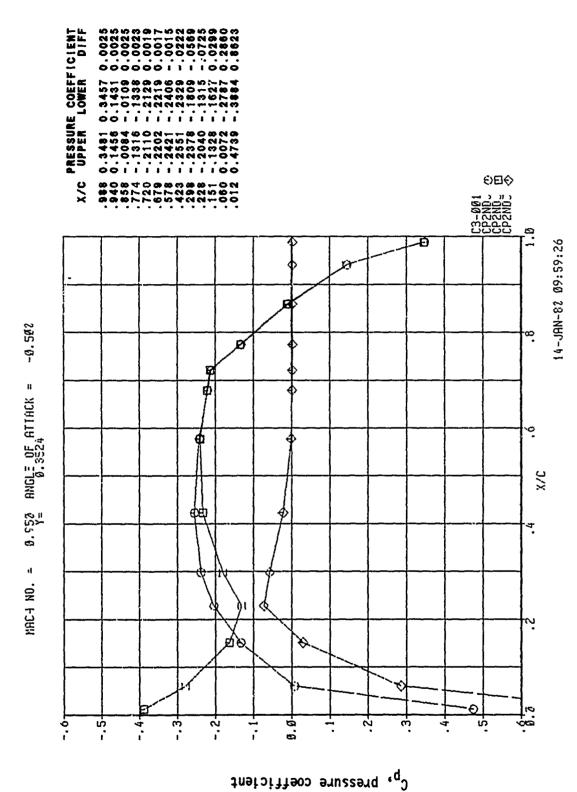


Figure

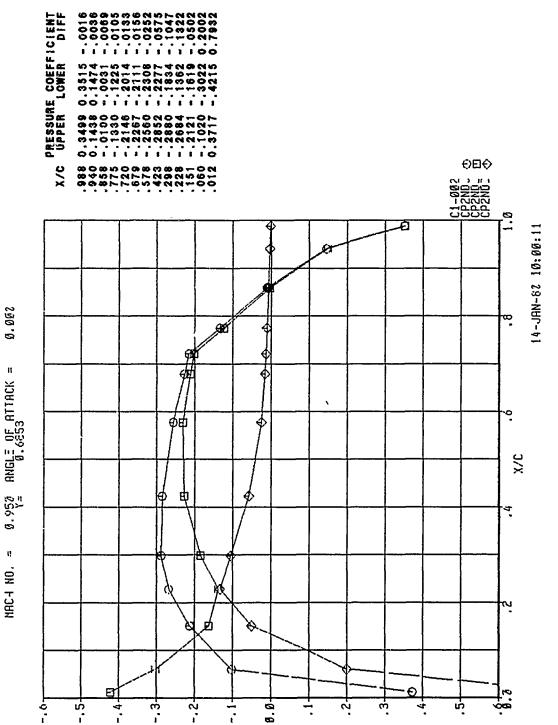
 $C_{\mathbf{p}}$, pressure coefficient



C_p, pressure coefficient

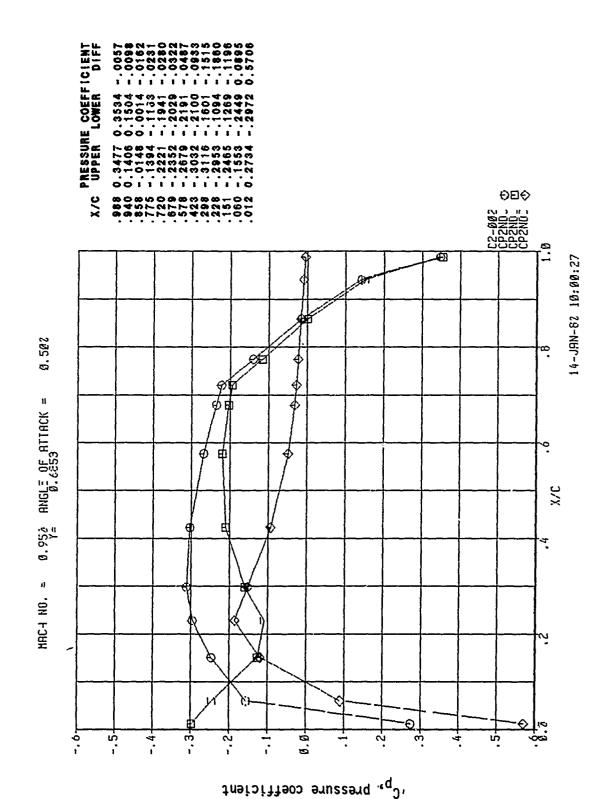


93, Chordwise Pressure Distribution, Steady, Configuration 1

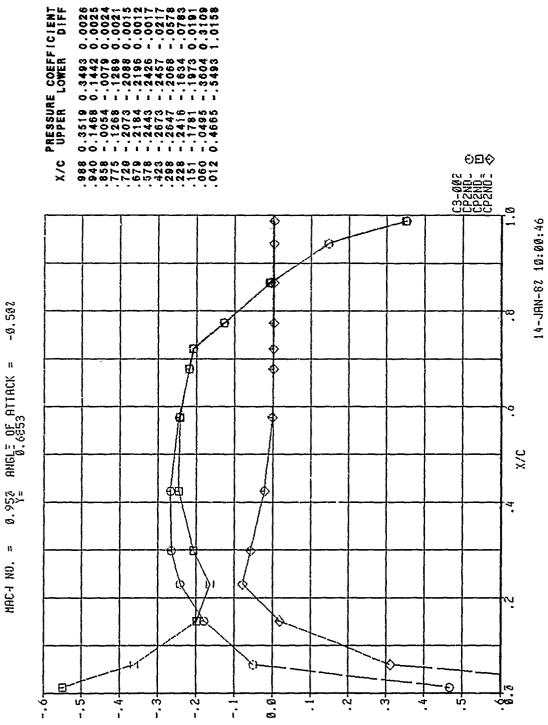


94, Chordwise Pressure Distribution, Steady, Configuration 1 Figure

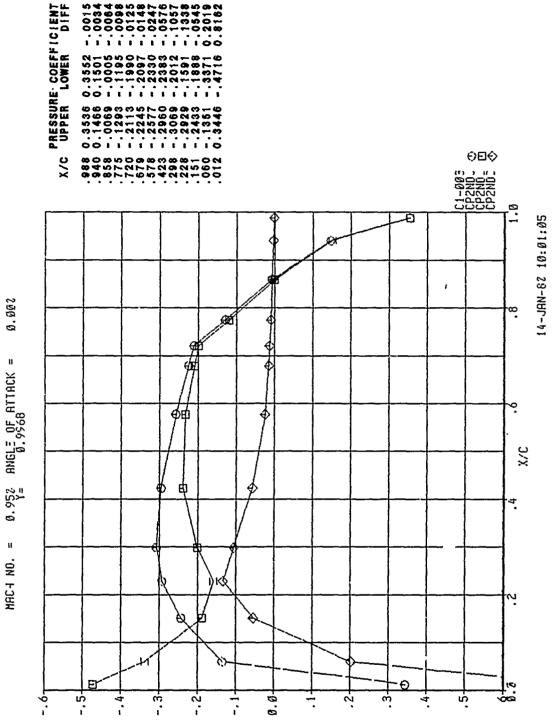
the pressure coefficient



ure 95, Chordwise Pressure Distribution, Steady, Configuration 1.



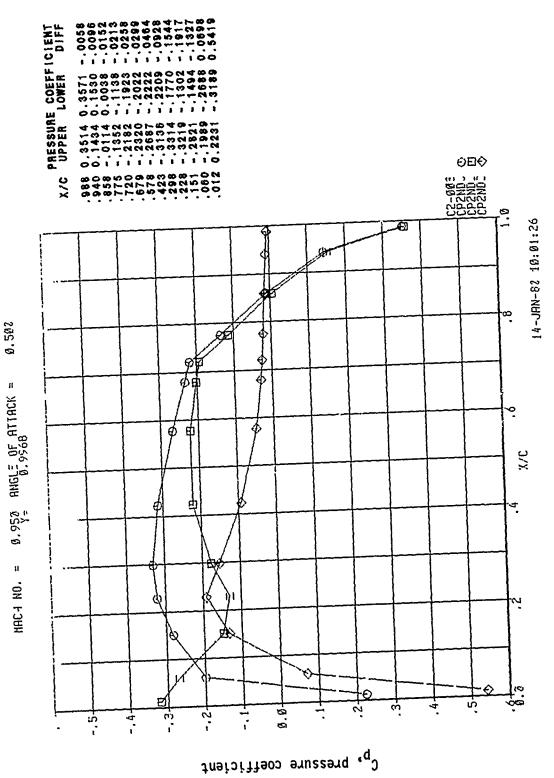
C_p, pressure coefficient



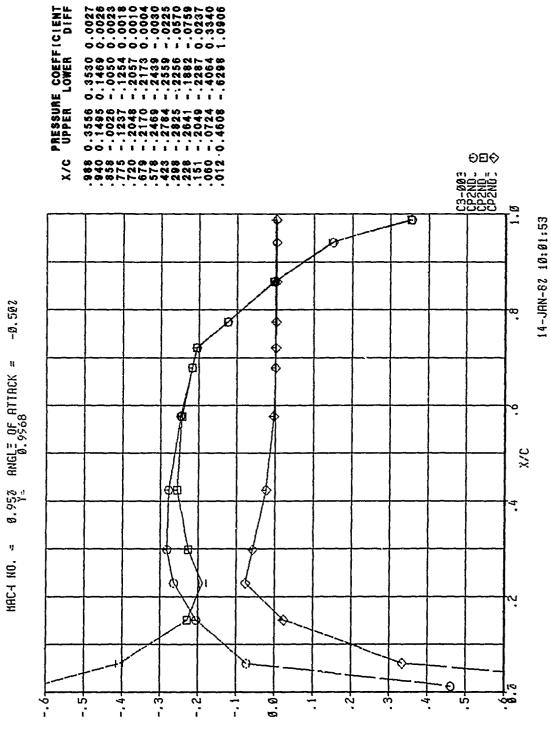
Figure

97, Chordwise Pressure Distribution, Steady, Configuration

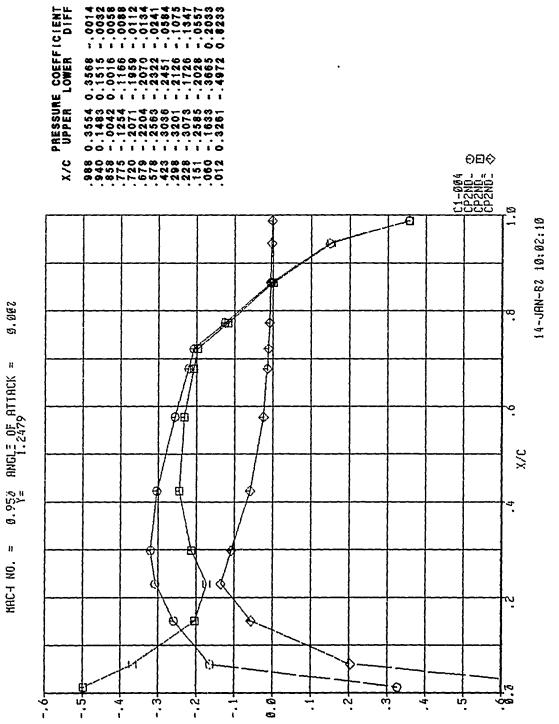
 $C_{\rm p}$, pressure coefficient



e 98, Chordwise Pressure Distribution, Steady, Configuration 1

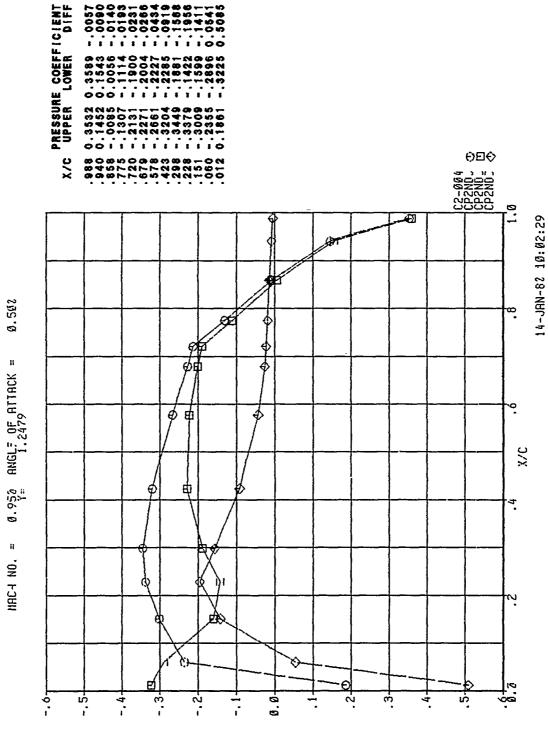


 $\sigma_{\rm p_3}$ pressure coefficient



e 100, Chordwise Pressure Distribution, Steady, Configuration

 $C_{\mathbf{p}}$, pressure coefficient



Jupipitheoc enuccent (q

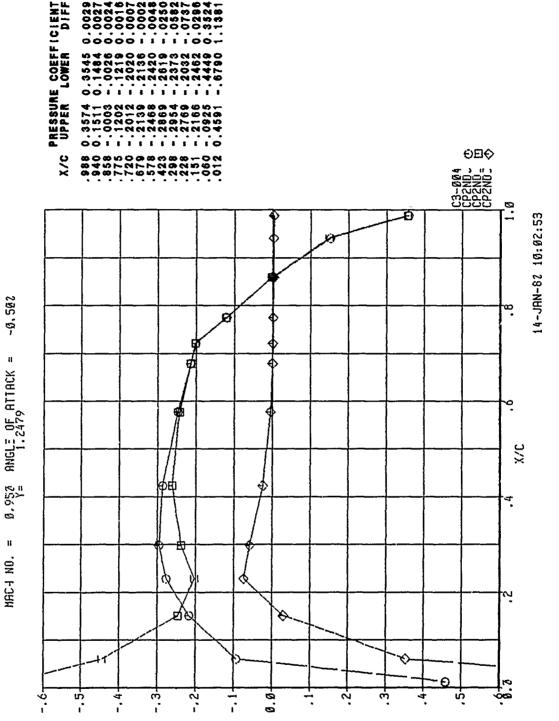
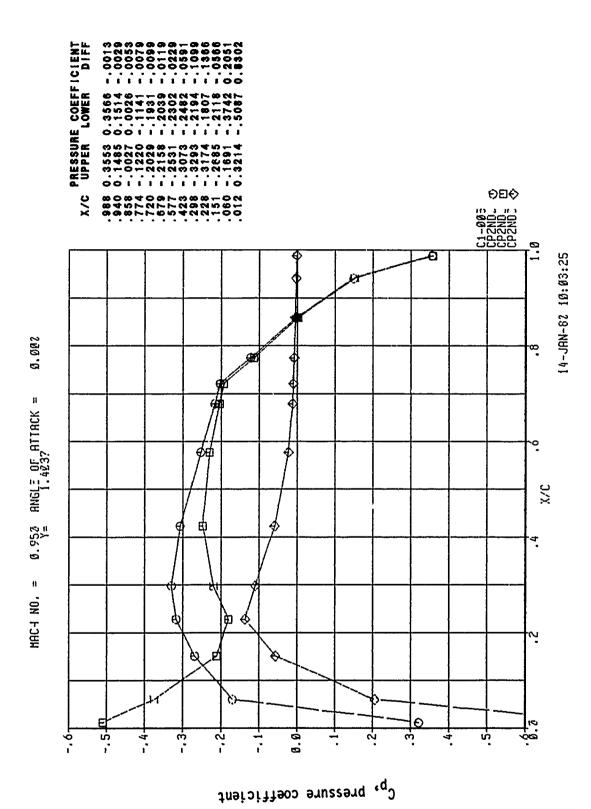
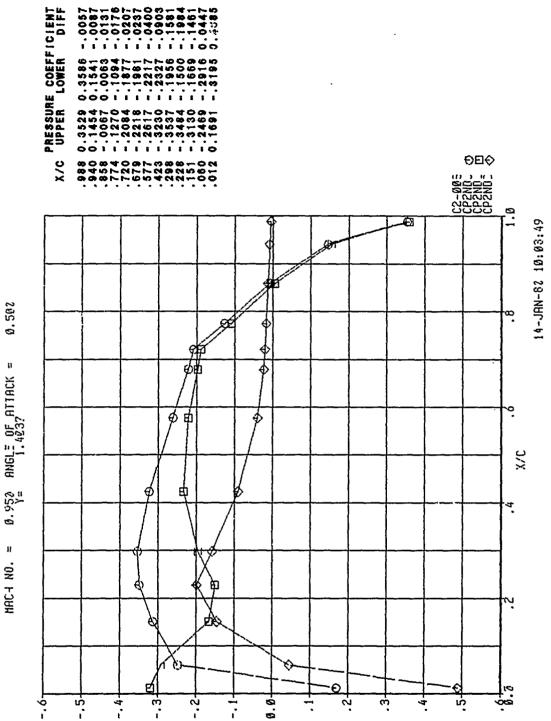


Figure 102, Chordwise Pressure Distribution, Steady, Configuration

 $c_{\mathbf{p}}$, pressure coefficient



103, Chordwise Pressure Distribution, Steady, Configuration 1 Figure

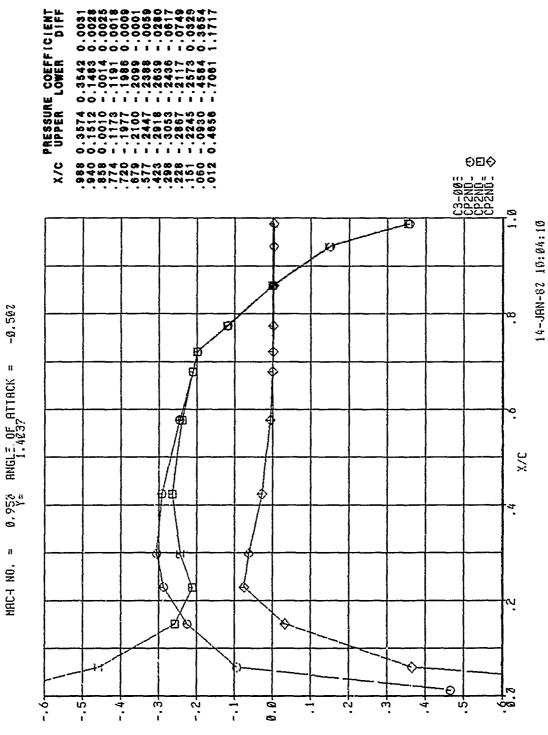


Figure

104, Chordwise Pressure Distribution, Steady, Configuration

137

 $C_{\mathbf{p}}$, pressure coefficient



 $c_{
m p}$, pressure coefficient

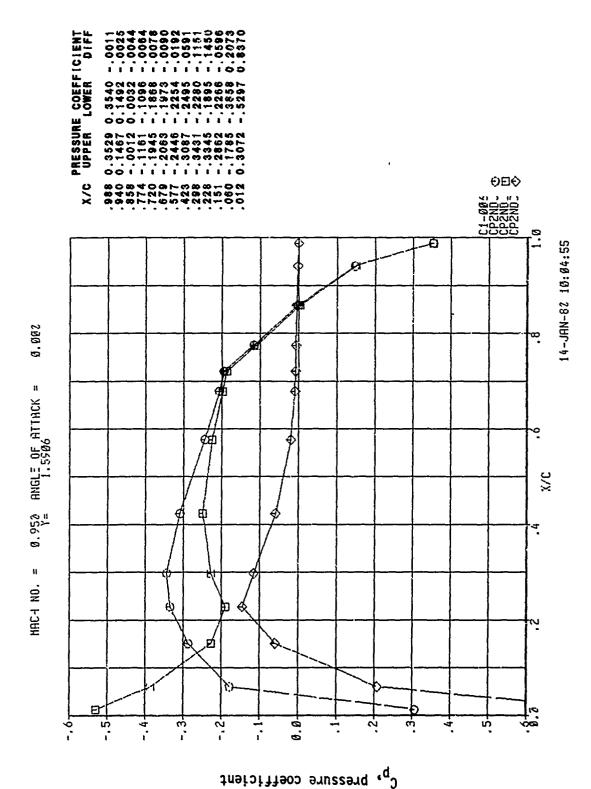


Figure 106, Chordwise Pressure Distribution, Steady, Configuration 1

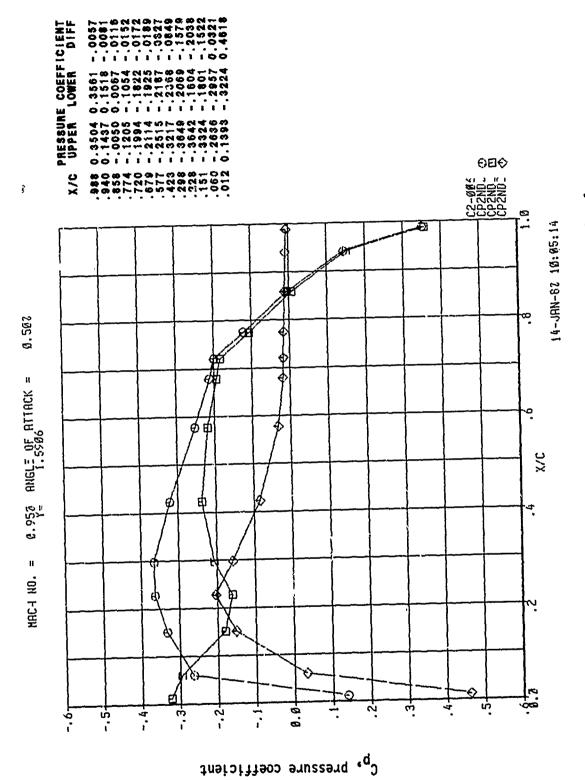
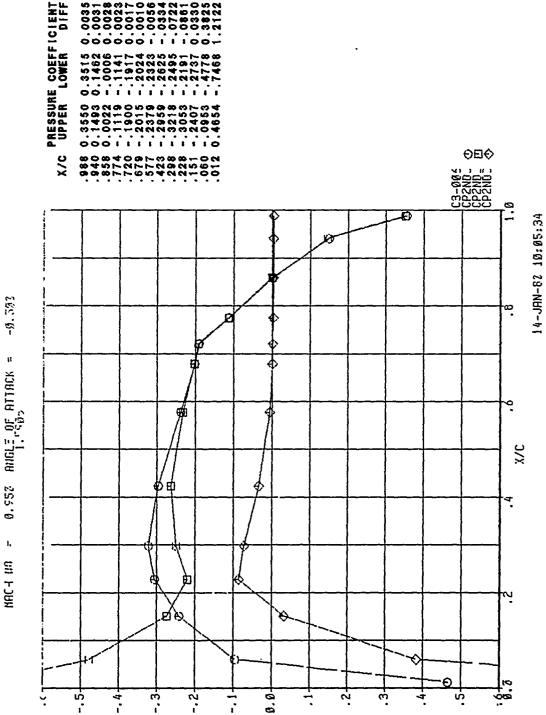
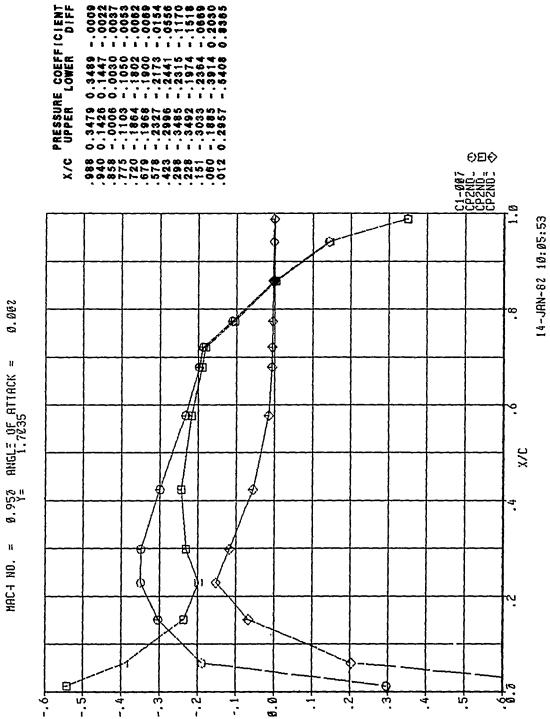


Figure 107, Chordwise Pressure Distribution, Steady, Configuration 1

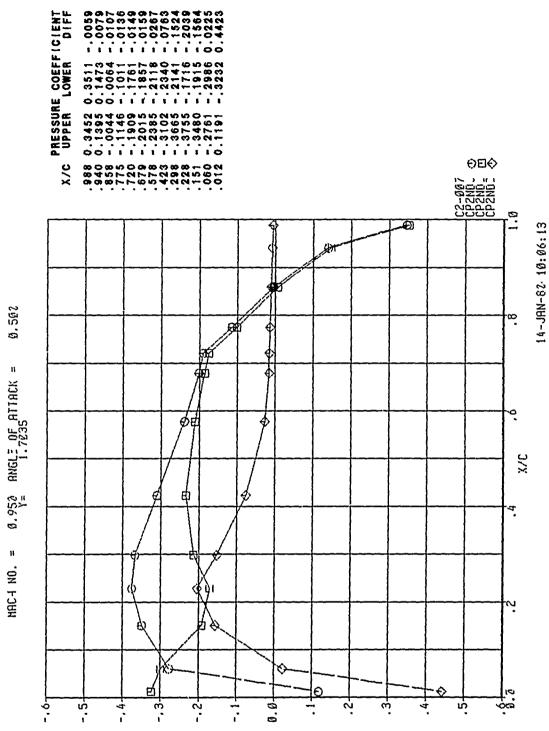


C_p, pressure coefficient

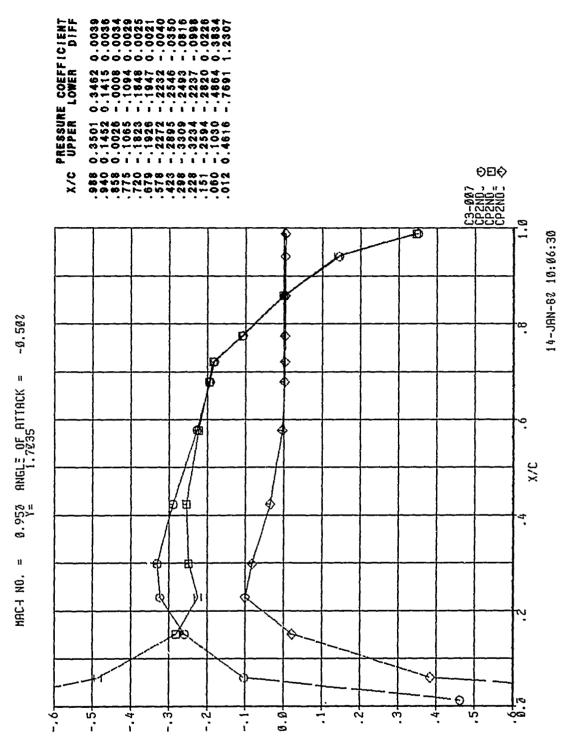


. Д

 $C_{\mathbf{p}}$, pressure coefficient



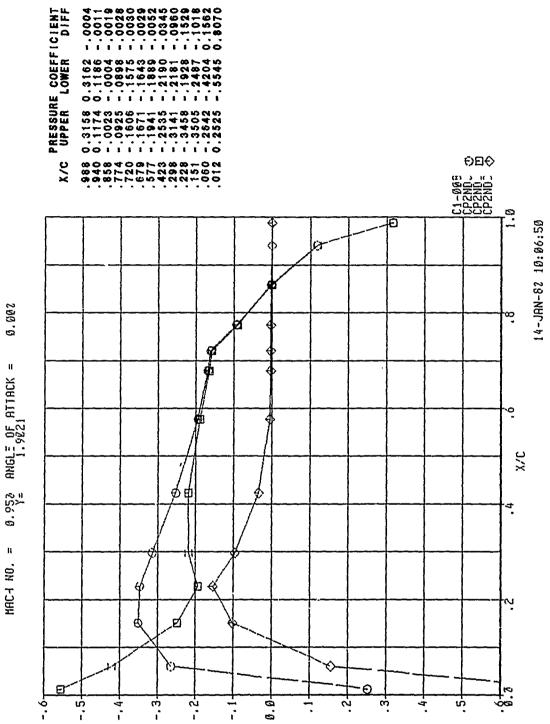
Jnefoiffeoo enusserd _{(q})



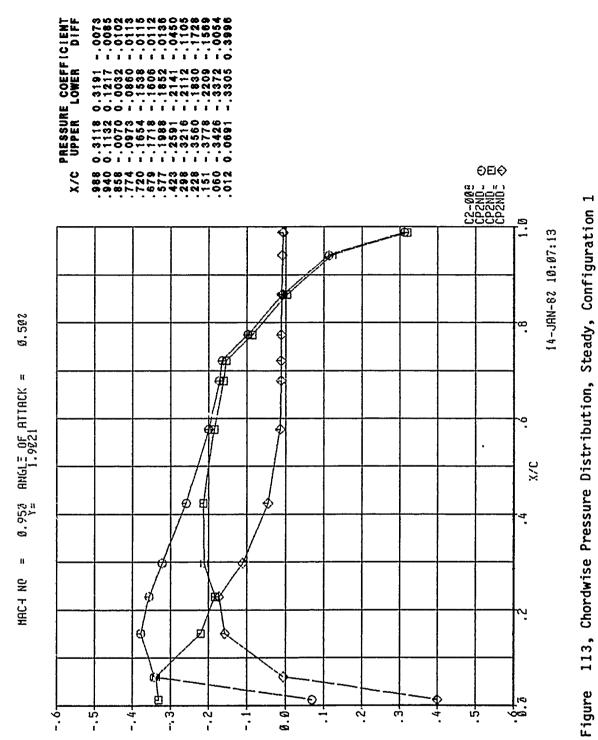
Figure

1

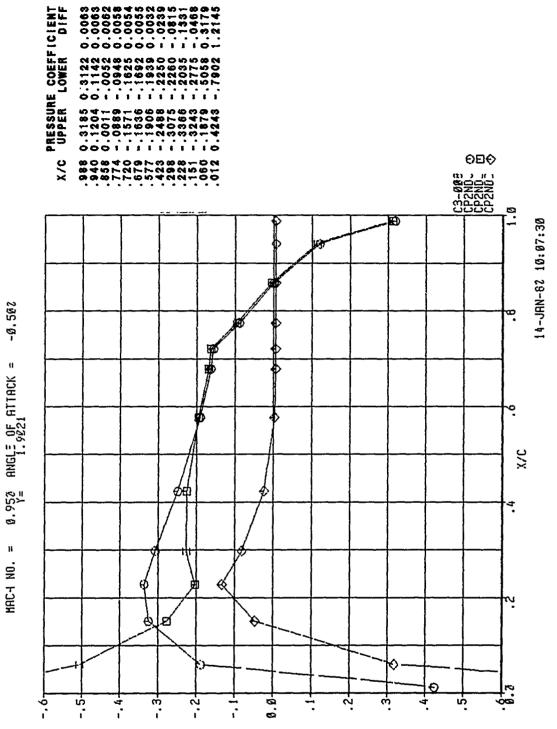
C_p, pressure coefficient



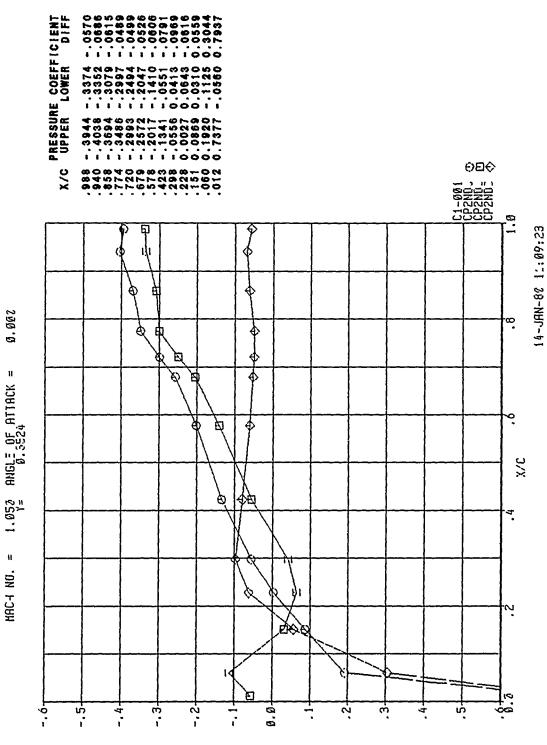
 $c_{\mathbf{q}}$, pressure coefficient



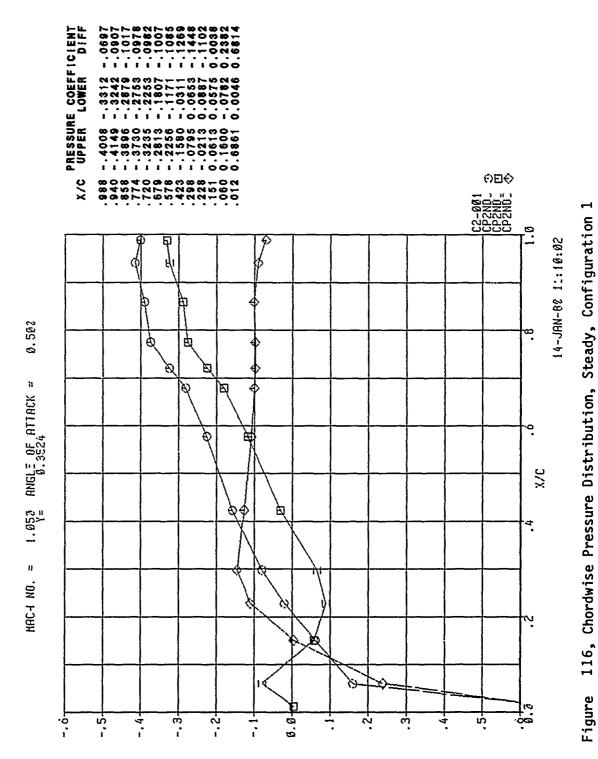
 $c_{
m p}$, pressure coefficient



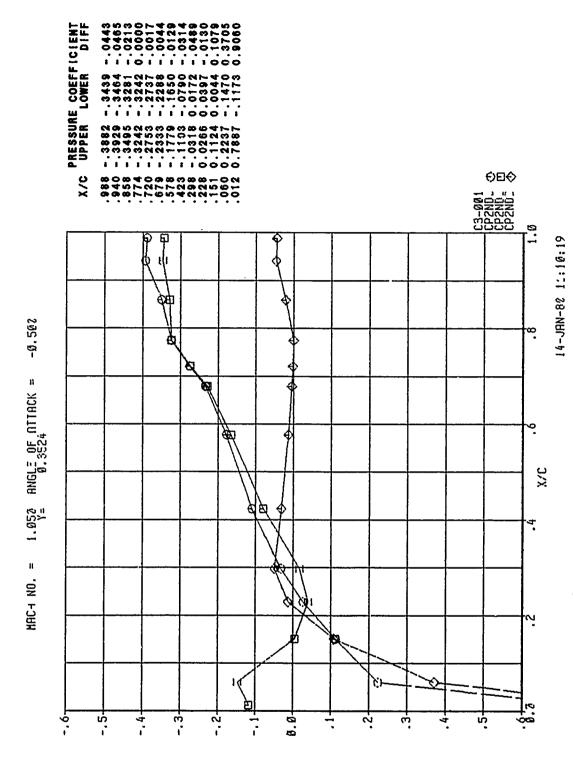
C_p, pressure coefficient



 $c_{
m p}$, pressure coefficient

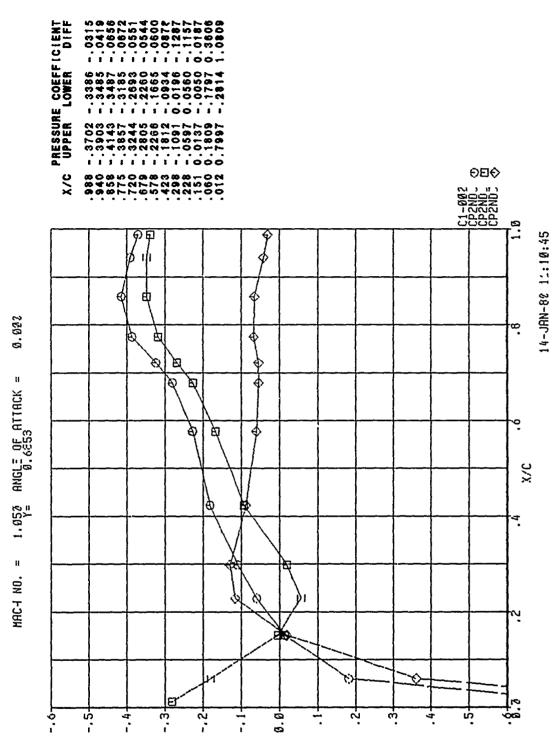


 $\sigma_{\rm p}$, pressure coefficient

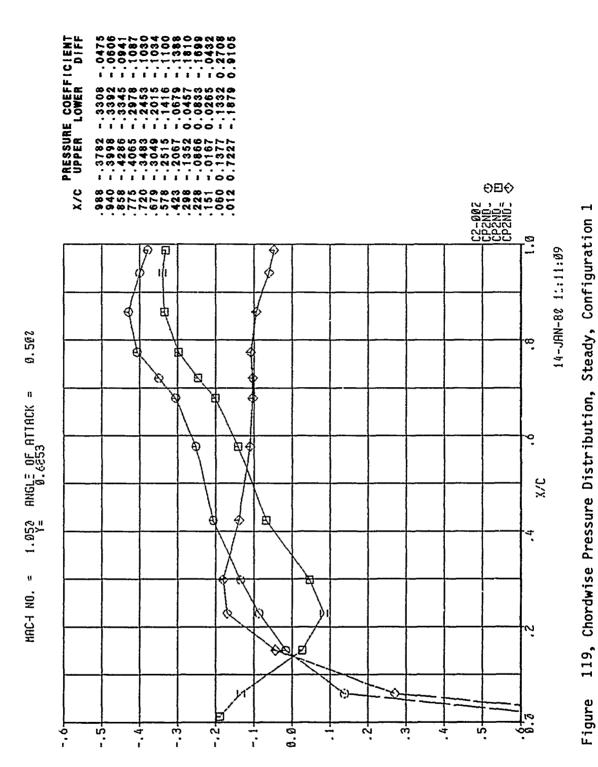


117, Chordwise Pressure Distribution, Steady, Configuration Figure

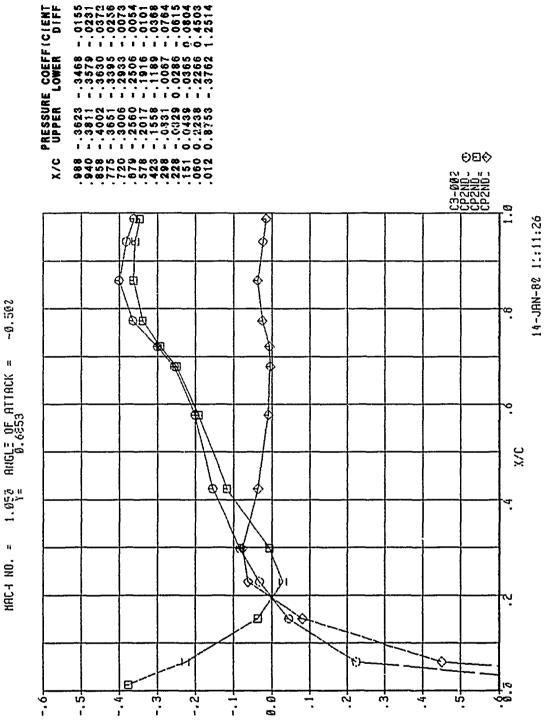
 $C_{\mathbf{p}}$, pressure coefficient



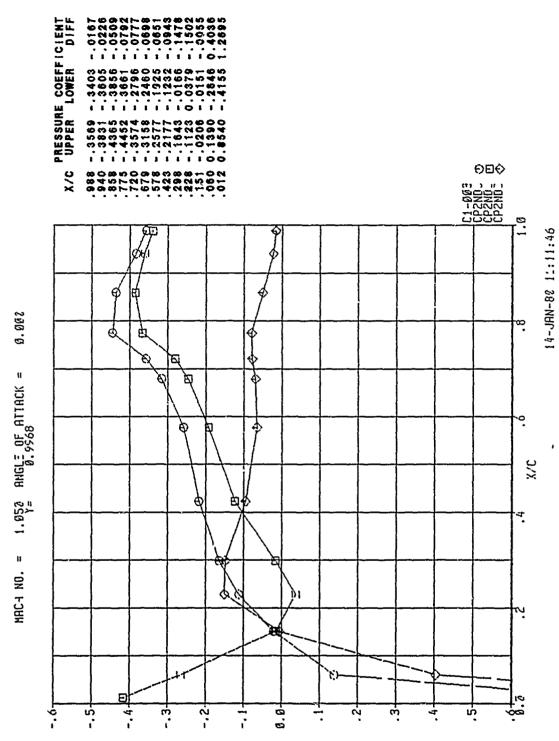
 $\mathsf{c}_{\mathsf{p}},$ pressure coefficient



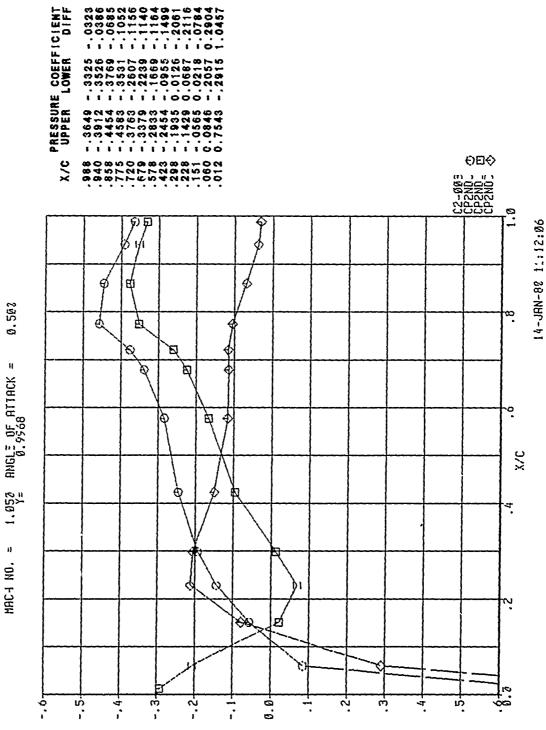
Cp, pressure coefficient



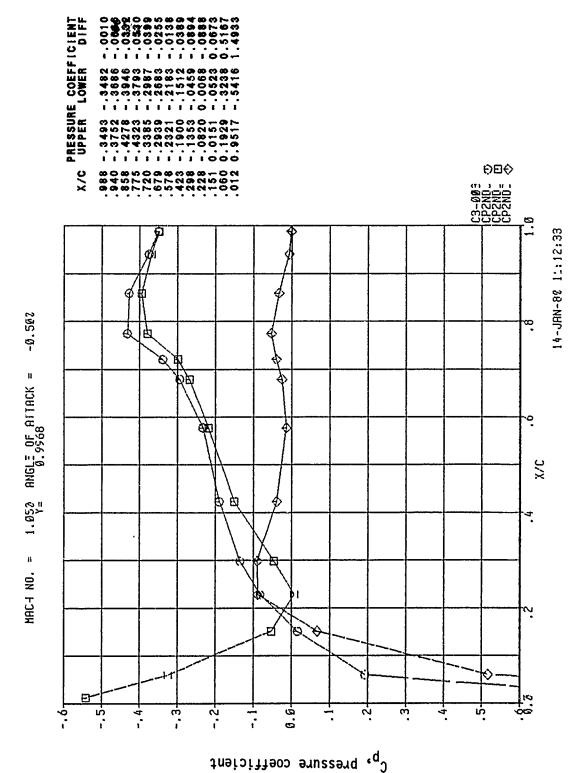
C_p, pressure coefficient



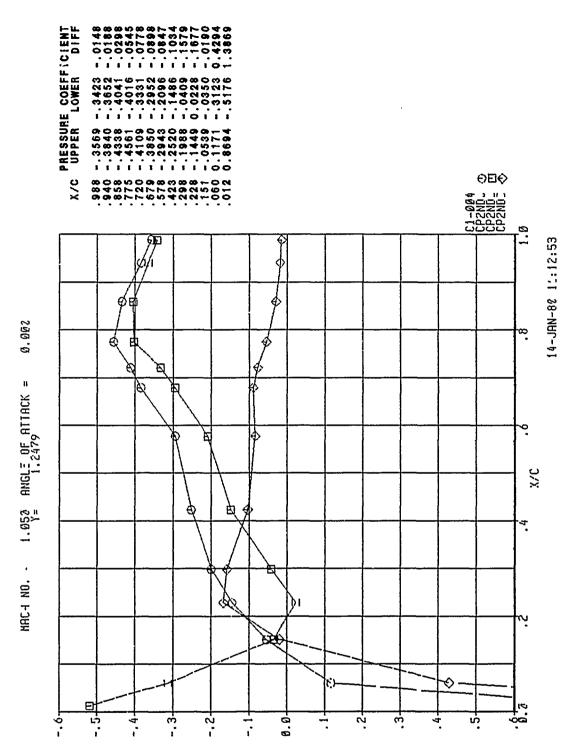
C_p, pressure coefficient



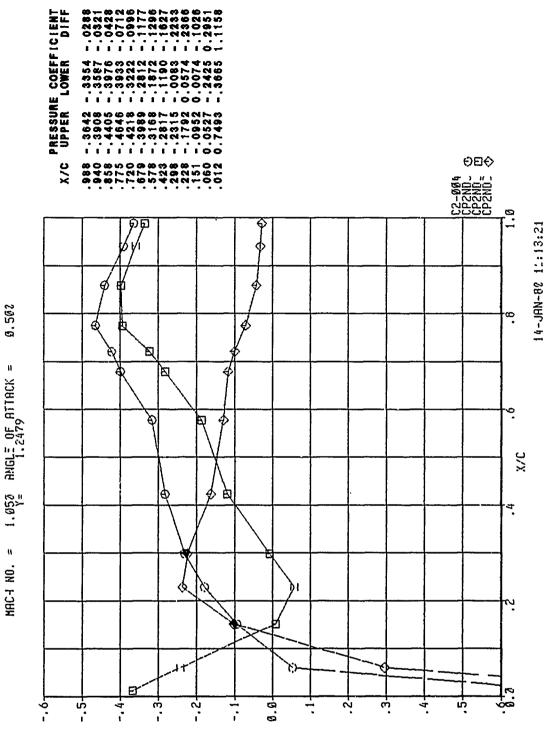
 $C_{\mathbf{p}}$, pressure coefficient



123, Chordwise Pressure Distribution, Steady, Configuration Figure



Cp. pressure coefficient



Figure

125, Chordwise Pressure Distribution, Steady, Configuration

 $C_{\mathbf{p}}$, pressure coefficient

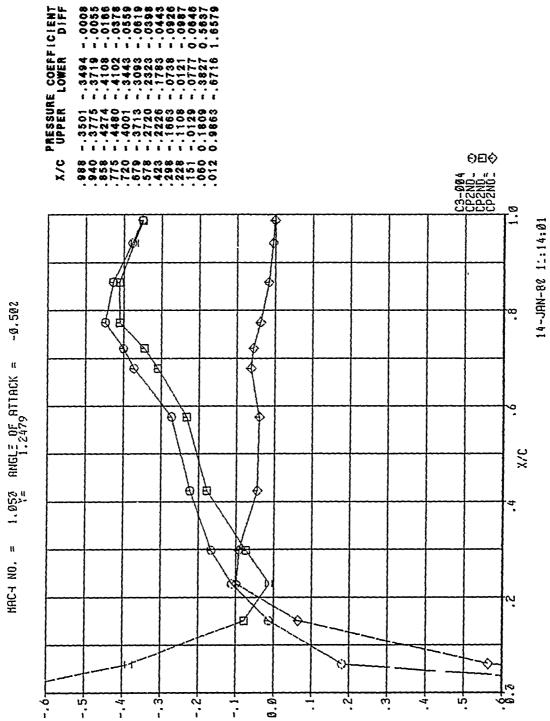
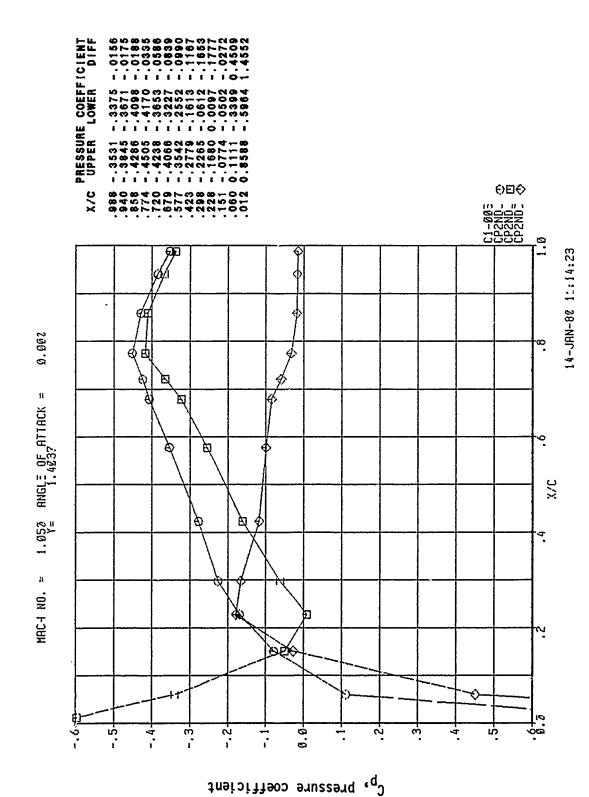
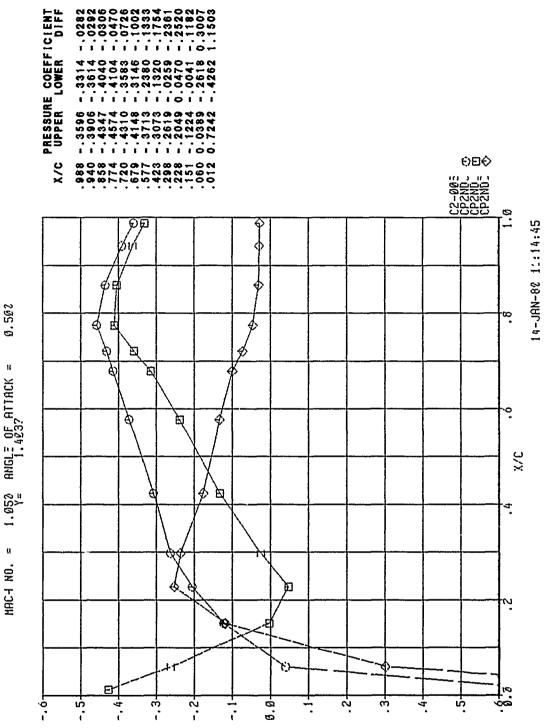


Figure 126, Chordwise Pressure Distribution, Steady, Configuration 1

 C_{p} , pressure coefficient

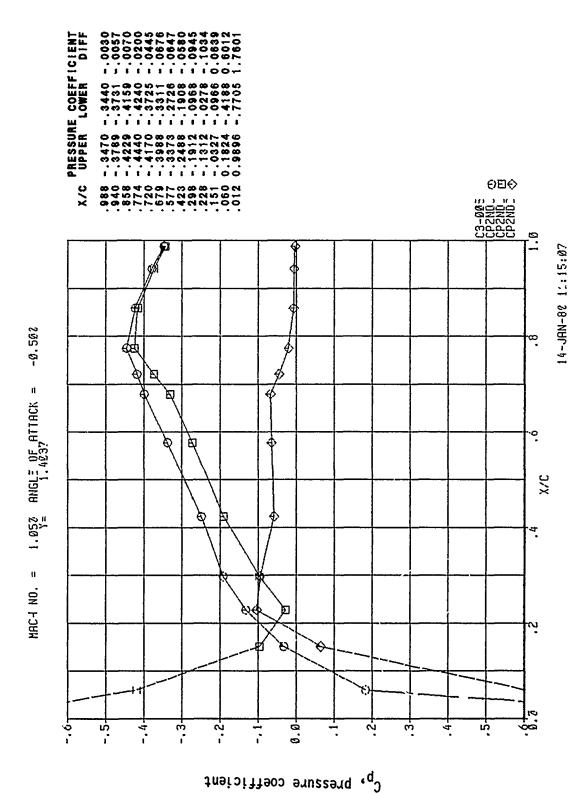


127, Chordwise Pressure Distribution, Steady, Configuration Figure

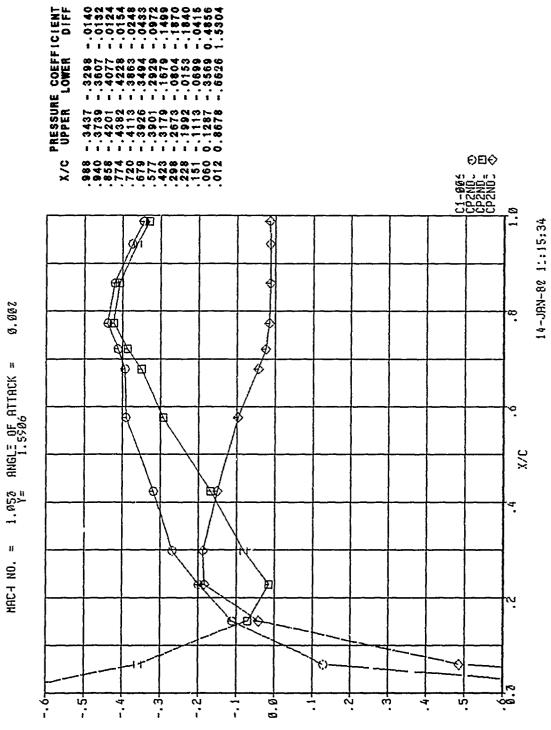


ure 128, Chordwise Pressure Distribution, Steady, Configuration 1

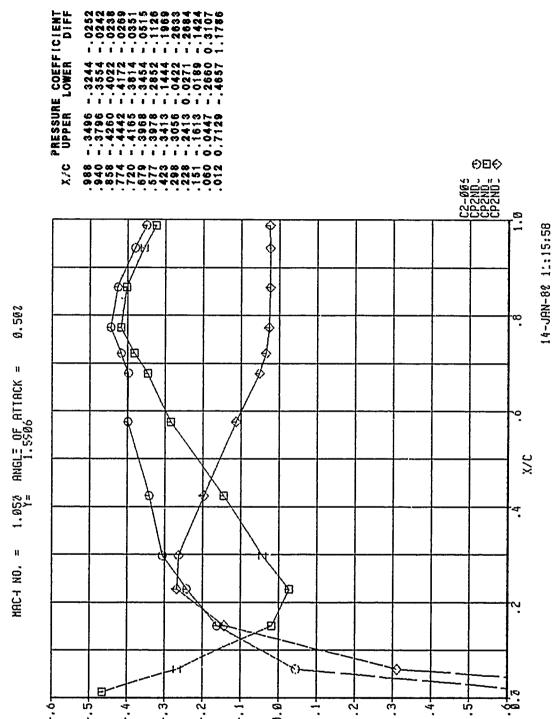
 C_{p} , pressure coefficient



igure 129, Chordwise Pressure Distribution, Steady, Configuration



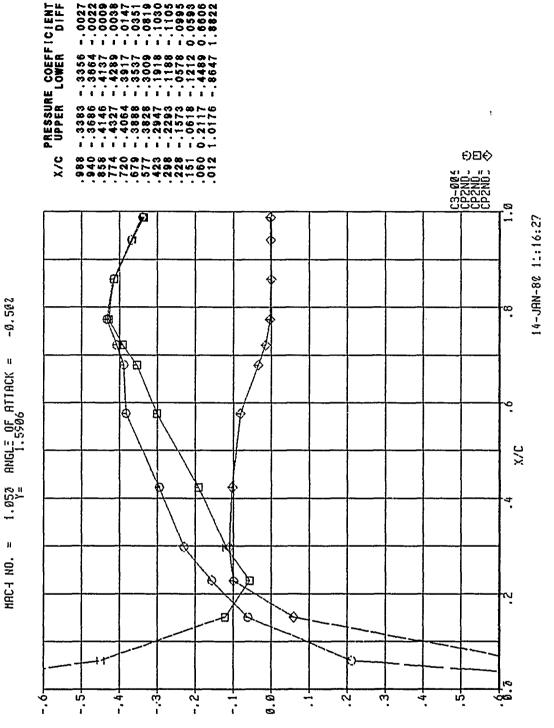
C_p, pressure coefficient



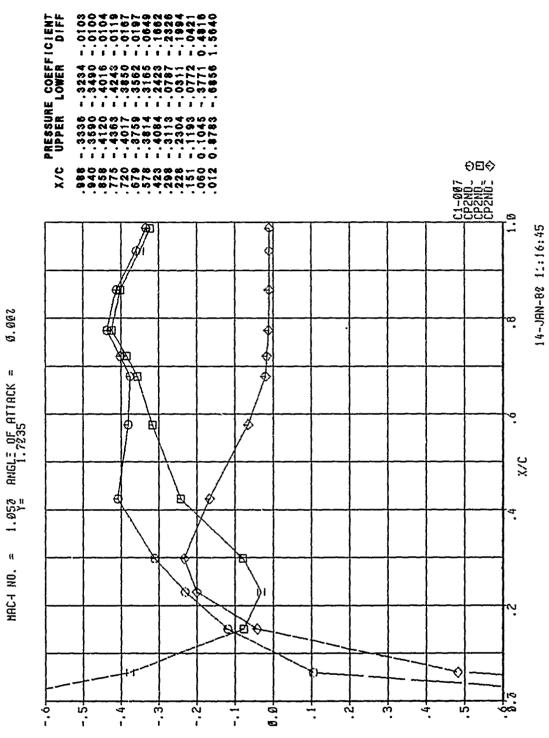
Figure

131, Chordwise Pressure Distribution, Steady, Configuration 1

the state coefficient q^{Q}

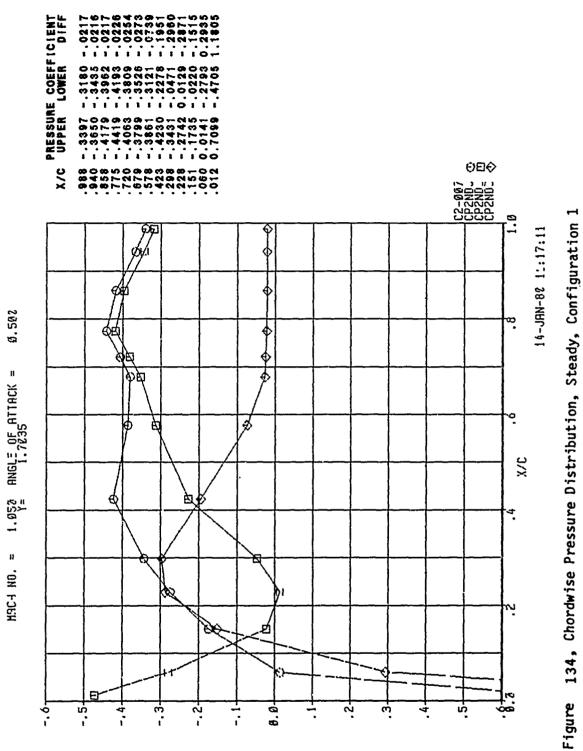


 $c_{
m p}$, pressure coefficient



4

 $c_{
m p}$, pressure coefficient



C_p, pressure coefficient

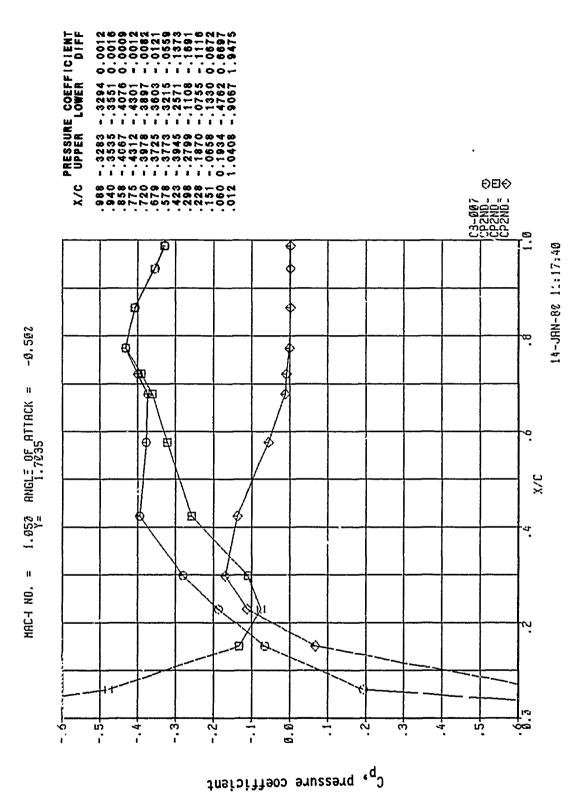
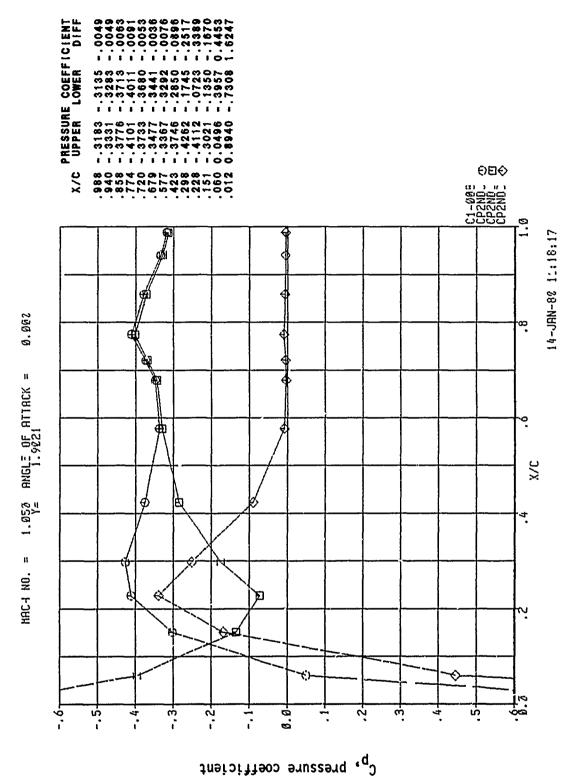
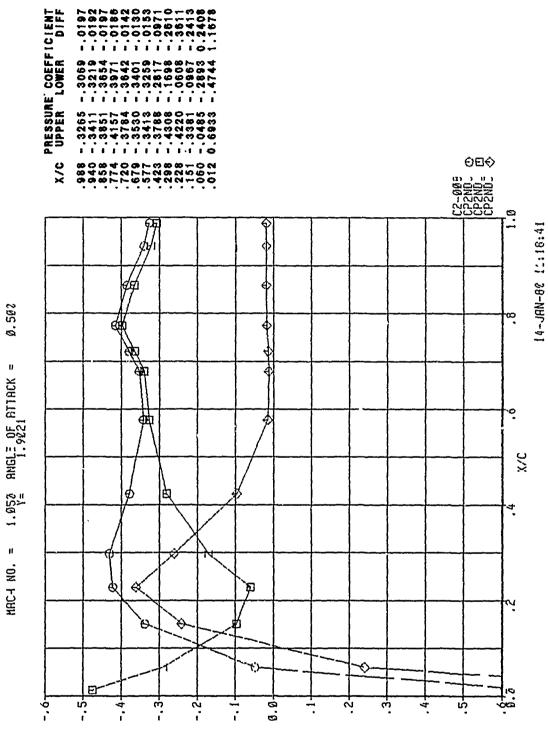


Figure 135, Chordwise Pressure Distribution, Steady, Configuration 1

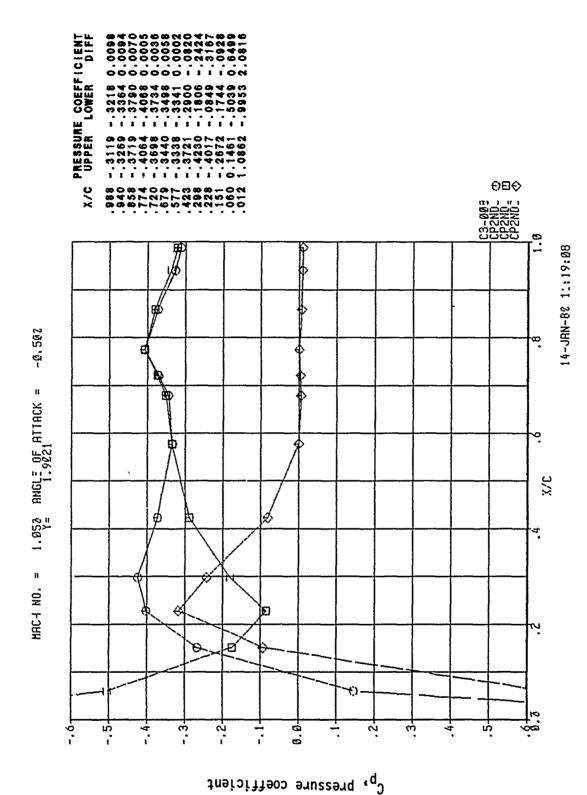


136, Chordwise Pressure Distribution, Steady, Configuration Figure

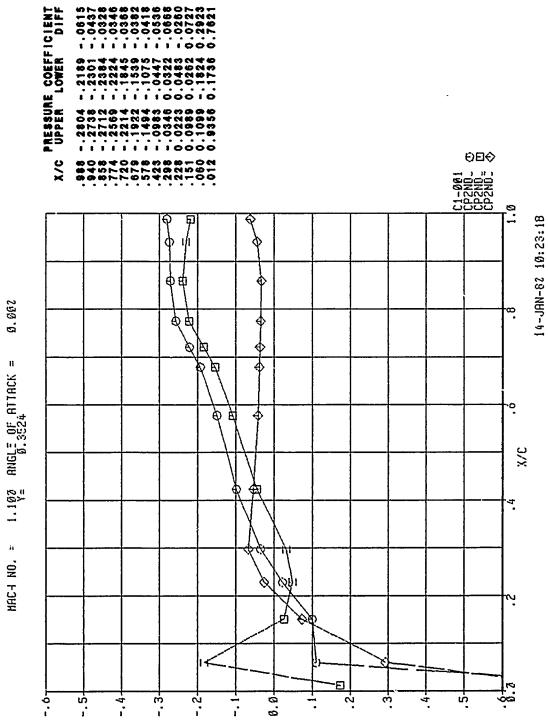


170

 C_{p} , pressure coefficient

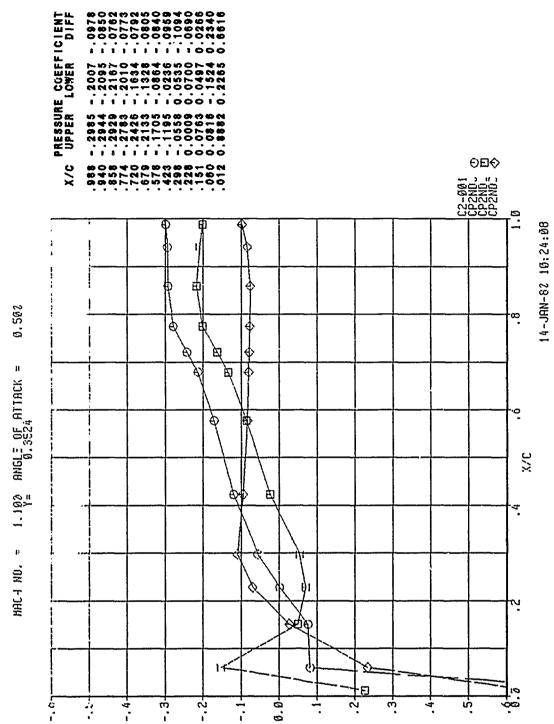


e 138, Chordwise Pressure Distribution, Steady, Configuration



139, Chordwise Pressure Distribution, Steady, Configuration

 $c_{
m p}$, pressure coefficient



140, Chordwise Pressure Distribution, Steady, Configuration

 $c_{
m q}$, pressure coefficient

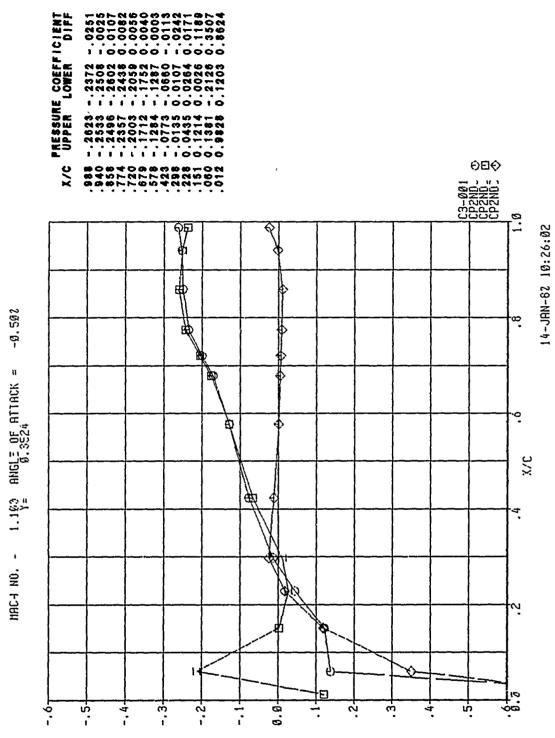


Figure 141 , Chordwise Pressure Distribution, Steady, Configuration 1

C_p, pressure coefficient

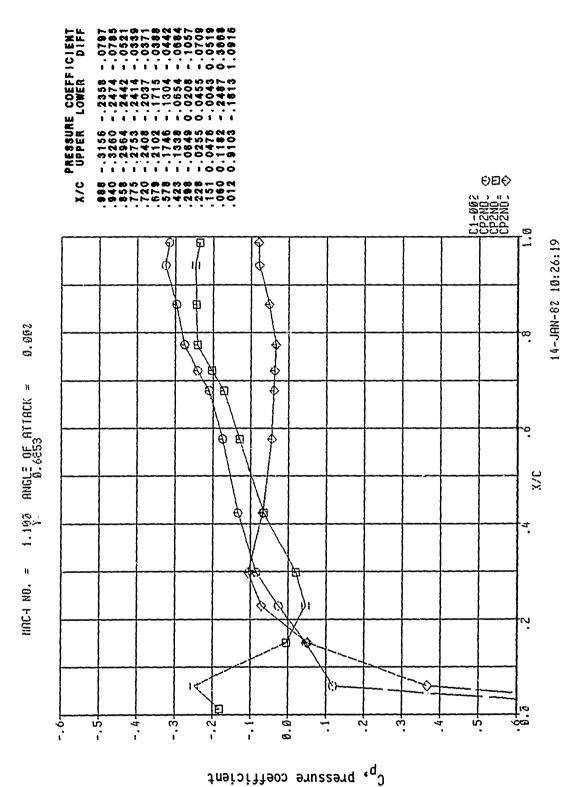


Figure 142, Chordwise Pressure Distribution, Steady, Configuration 1

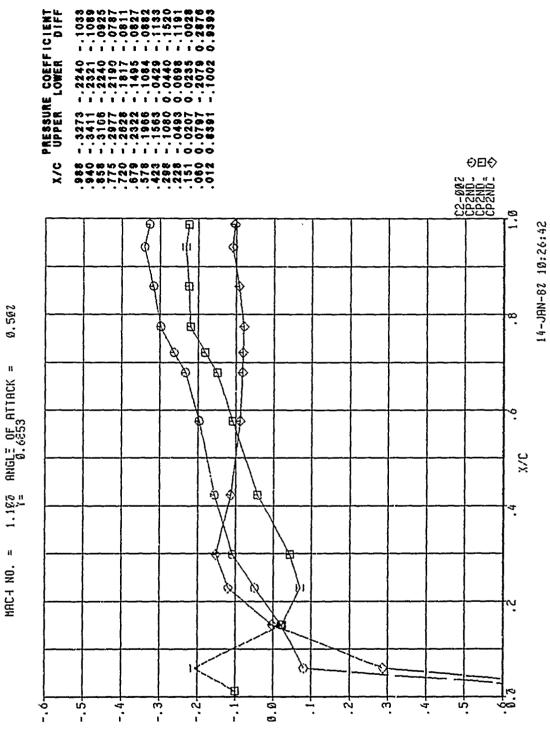


Figure 143, Chordwise Pressure Distribution, Steady, Configuration

 $\sigma_{\rm p}$, pressure coefficient

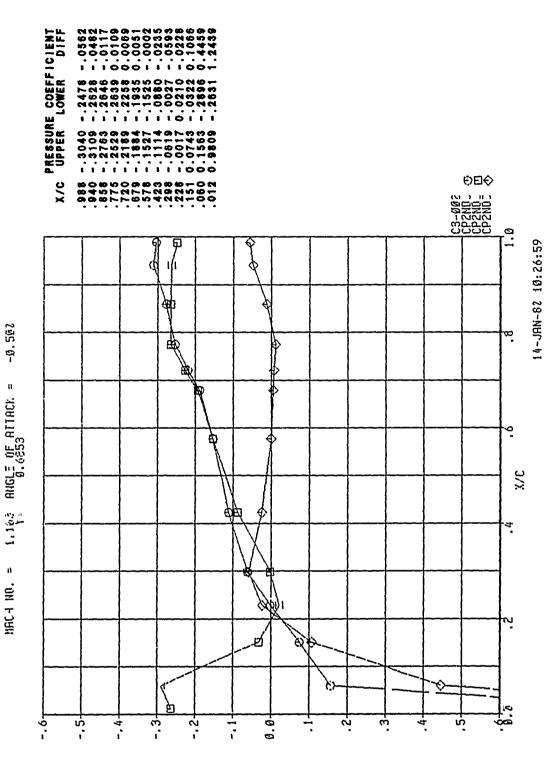


Figure 144, Chordwise Pressure Distribution, Steady, Configuration

C_p, pressure coefficient

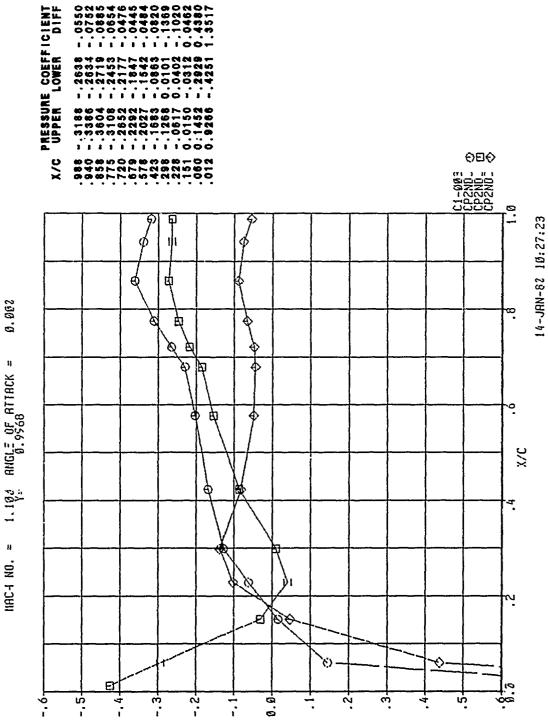


Figure 145, Chordwise Pressure Distribution, Steady, Configuration 1

 $C_{\mathbf{p}}$, pressure coefficient

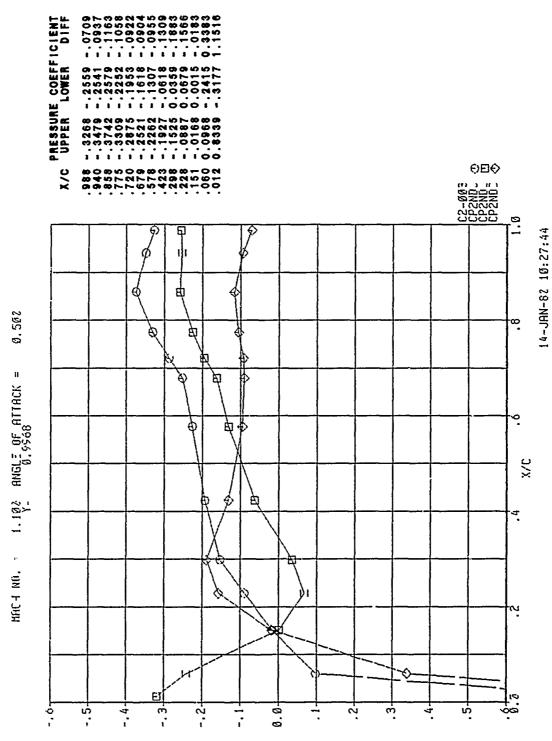


Figure 146, Chordwise Pressure Distribution, Steady, Configuration

 C_{p} , pressure coefficient

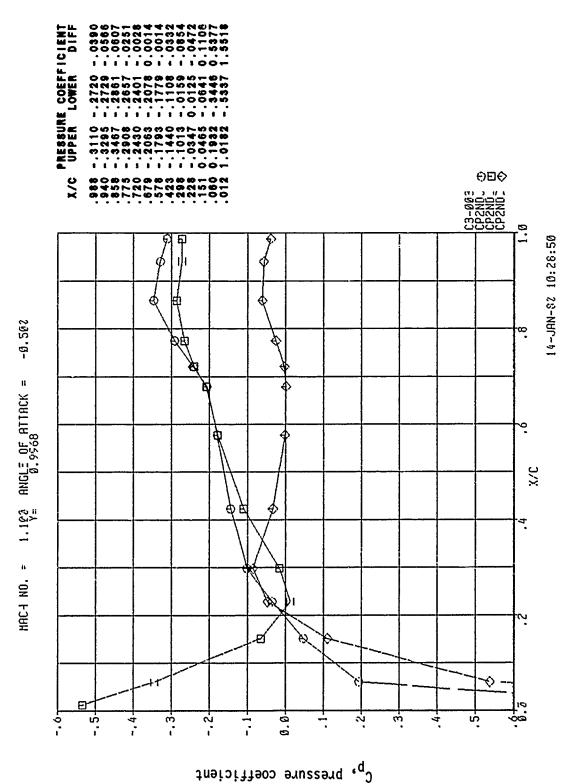
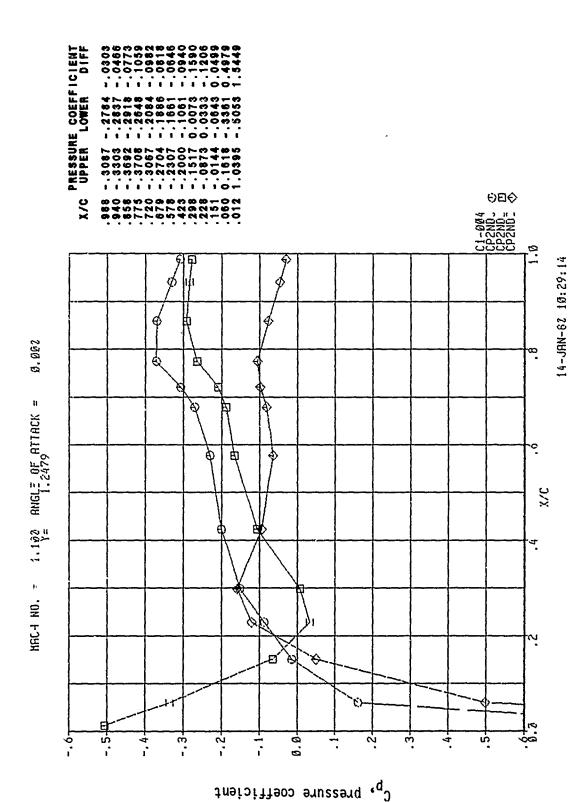


Figure 147, Chordwise Pressure Distribution, Steady, Configuration



ure 148, Chordwise Pressure Distribution, Steady, Configuration 1

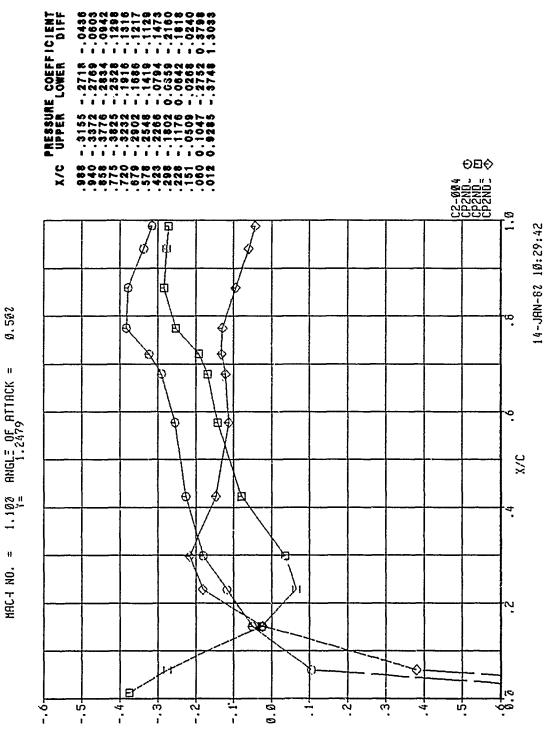


Figure 149, Chordwise Pressure Distribution, Steady, Configuration 1

C_p, pressure coefficient

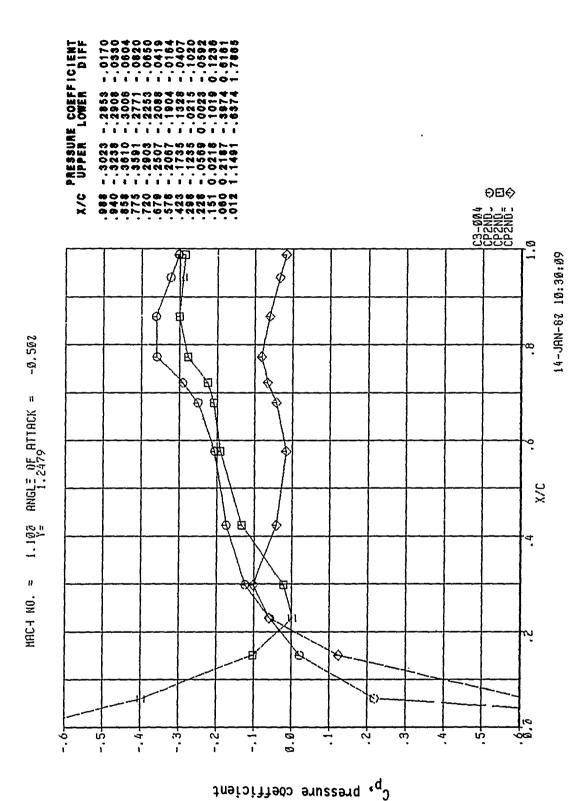


Figure 150, Chordwise Pressure Distribution, Steady, Configuration 1

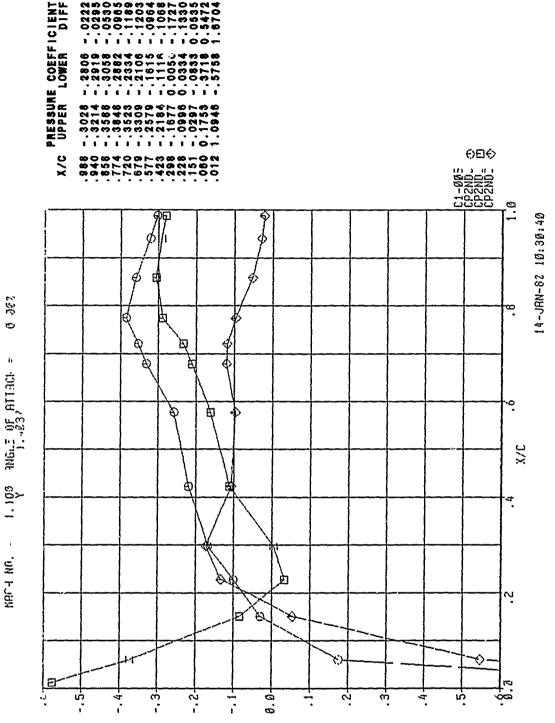


Figure 151, Chordwise Pressure Distribution, Steady, Configuration

 $C_{\mathbf{p}}$, pressure coefficient

KAF4 NG.

0.502

ANGLE OF ATTACK

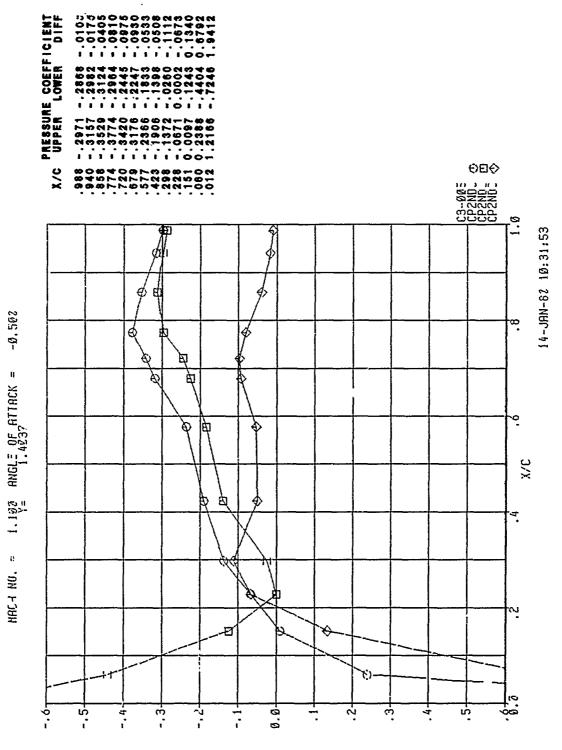
1.103

ij.

MAC4 NO.

152, Chordwise Pressure Distribution, Stgady, Configuration

C_p, pressure coefficient



e 153, Chordwise Pressure Distribution, Steady, Configuration 1

 $c_{\rm p}$, pressure coefficient

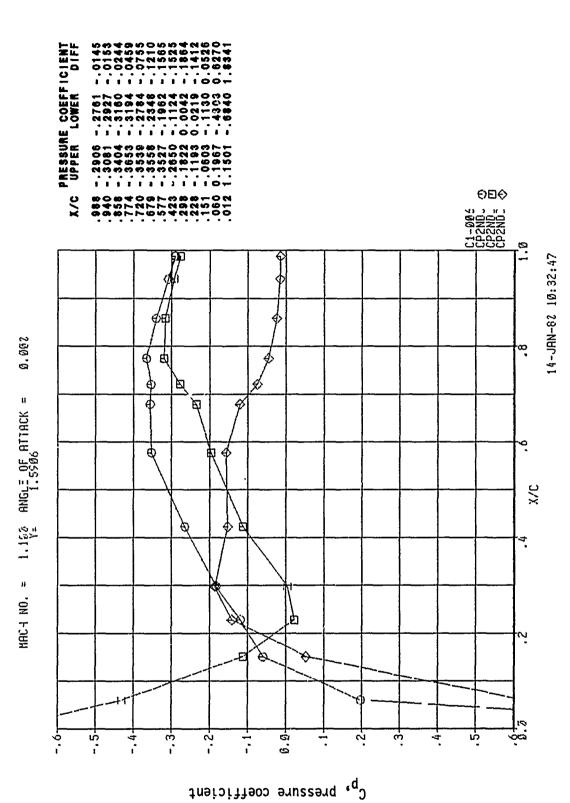
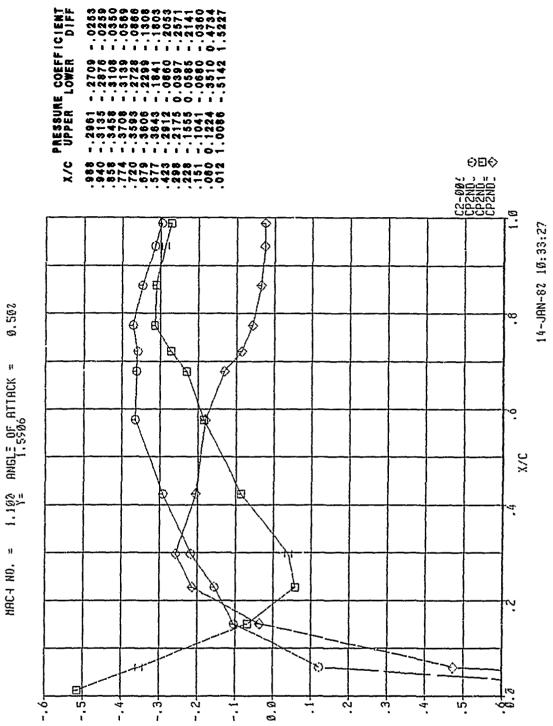


Figure 154, Chordwise Pressure Distribution, Steady, Configuration 1



155, Chardwise Pressure Distribution, Steady, Configuration 1

theisiffeos exuseard $\mathfrak{c}_{\mathsf{q}}^{\mathsf{J}}$

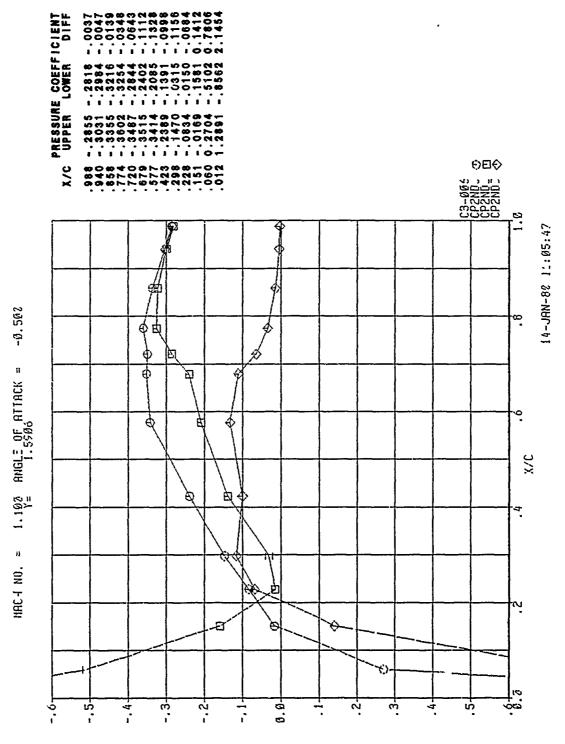
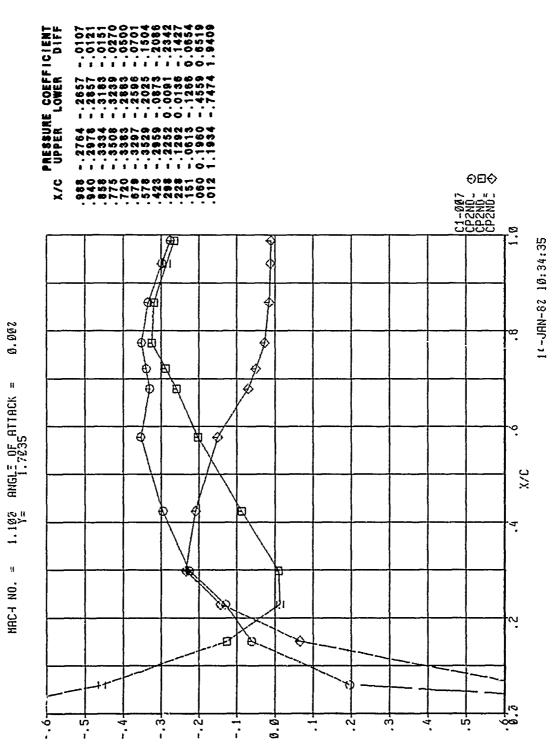


Figure 156, Chordwise Pressure Distribution, Steady, Configuration 1

 C_{p} , pressure coefficient



157, Chordwise Pressure Distribution, Steady, Configuration 1

C_p, pressure coefficient

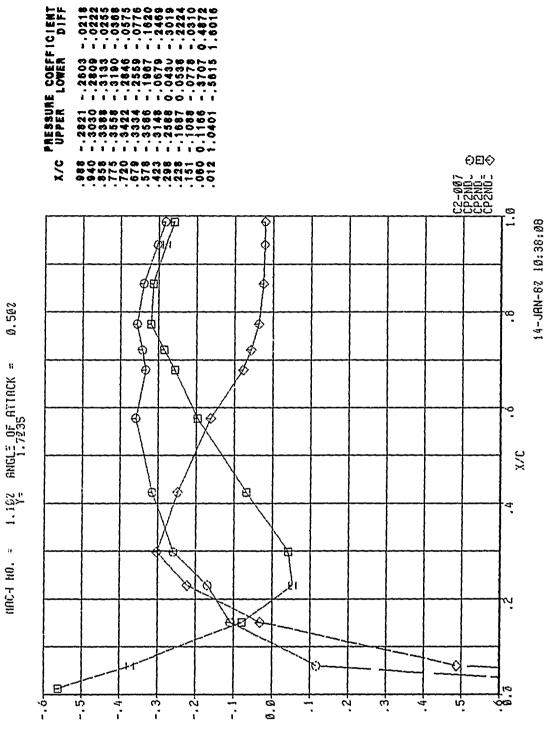


Figure 158, Chordwise Pressure Distribution, Steady, Configuration 1

 $C_{\mathbf{p}}$, pressure coefficient

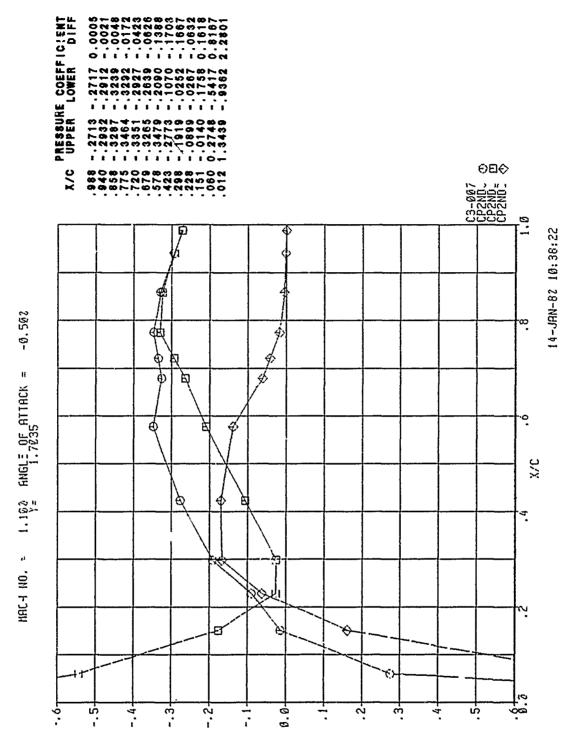
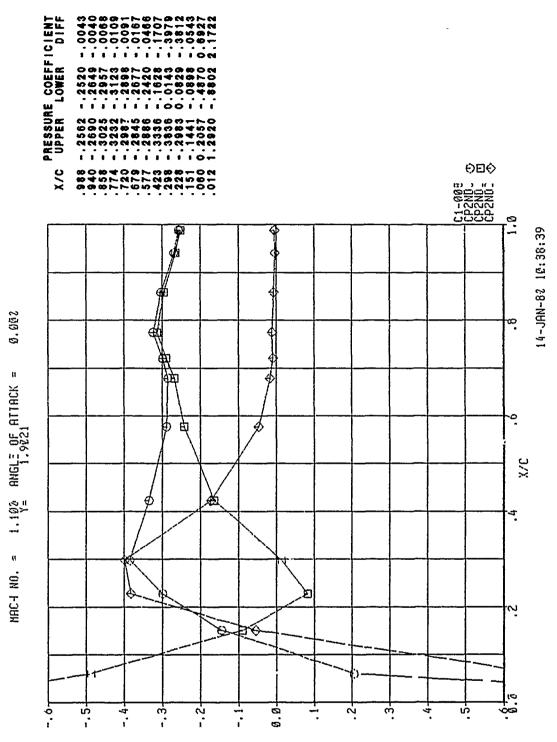


Figure 159, Chordwise Pressure Distribution, Steady, Configuration

 $\textbf{C}_{\textbf{p}}$ pressure coefficient



1

Figure 160, Chordwise Pressure Distribution, Steady, Configuration

 $C_{\mathbf{p}}$, pressure coefficient

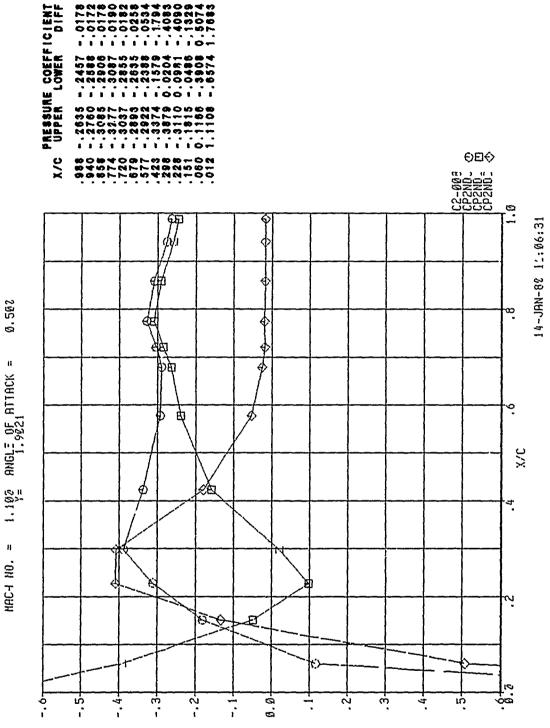
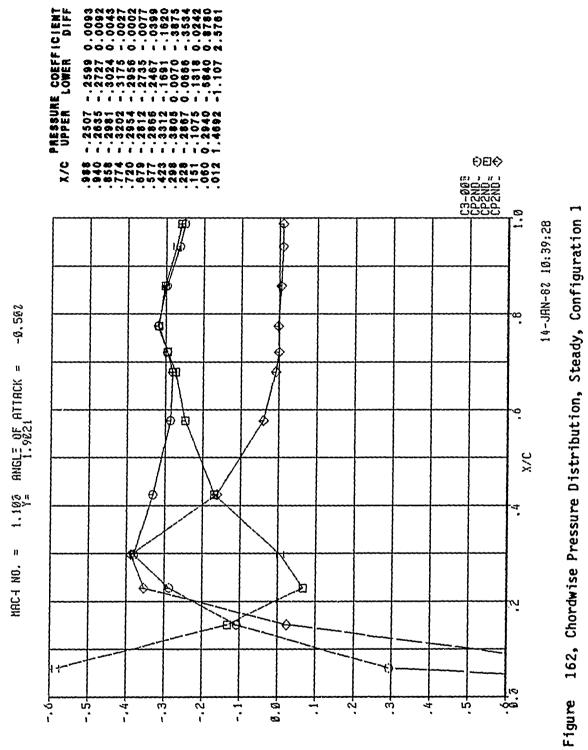


Figure 161, Chordwise Pressure Distribution, Steady, Configuration

 $C_{\mathbf{p}}$, pressure coefficient



Cp. pressure coefficient

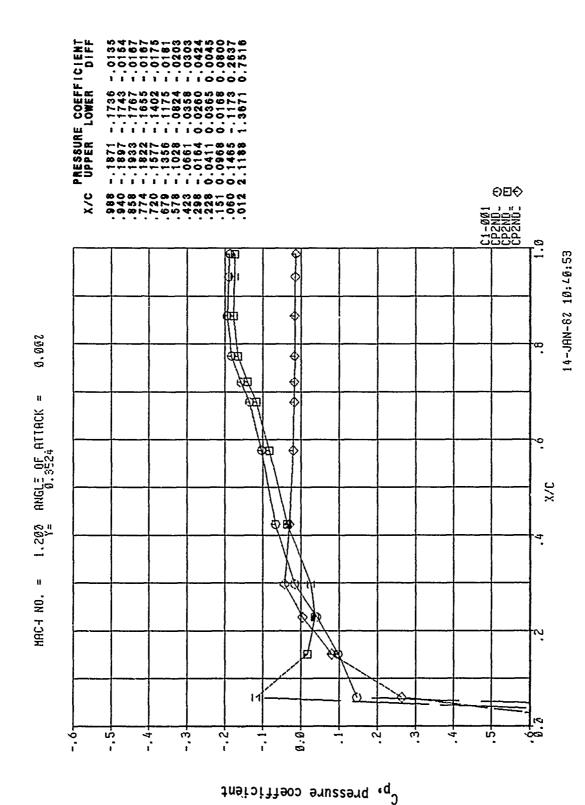


Figure 163, Chordwise Pressure Distribution, Steady, Configuration

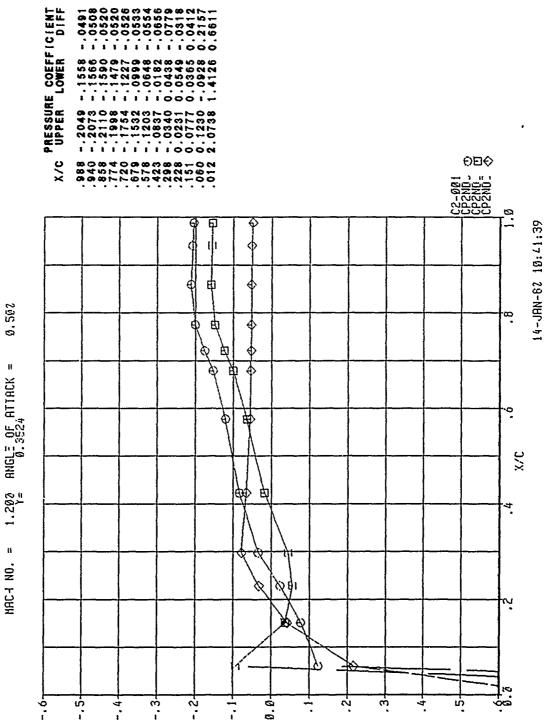
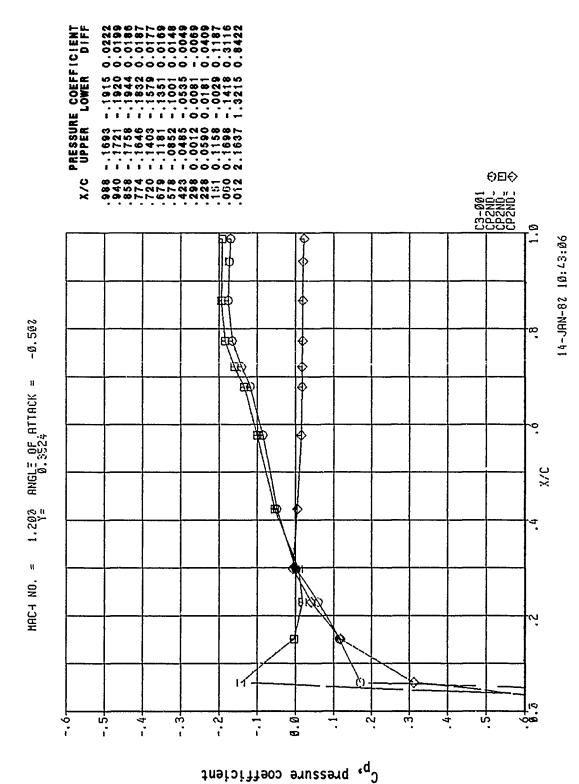


Figure 164, Chordwise Pressure Distribution, Steady, Configuration

 $\sigma_{\rm p}$, pressure coefficient



165, Chordwise Pressure Distribution, Steady, Configuration 1 Figure

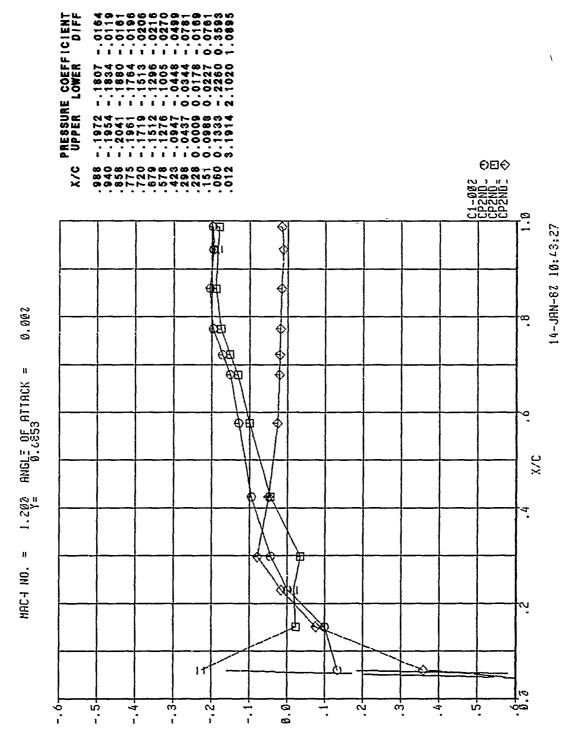


Figure 166, Chordwise Pressure Distribution, Steady, Configuration

The pressure coefficient

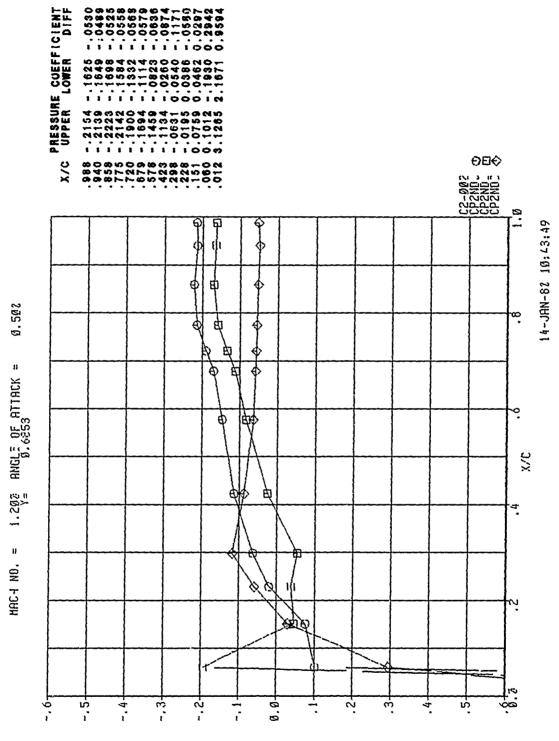


Figure 167, Chordwise Pressure Distribution, Steady, Configuration

Cp, pressure coefficient

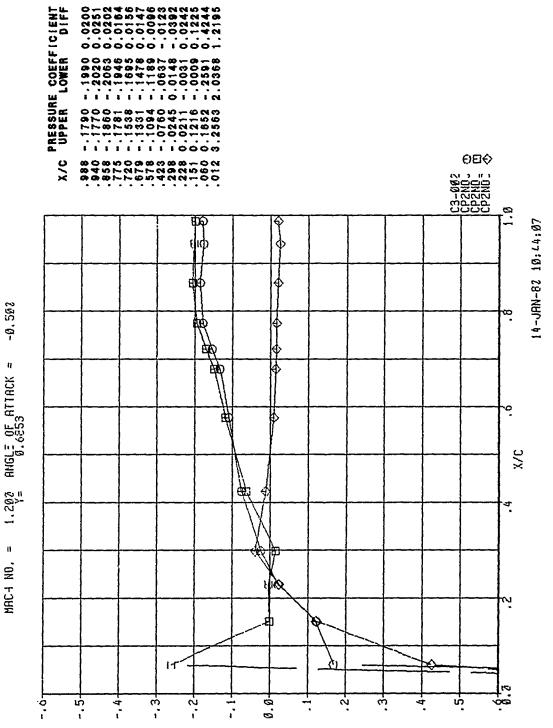


Figure 168, Chordwise Pressure Distribution, Steady, Configuration

finatioitheop enussand ${}_{
m tq}$

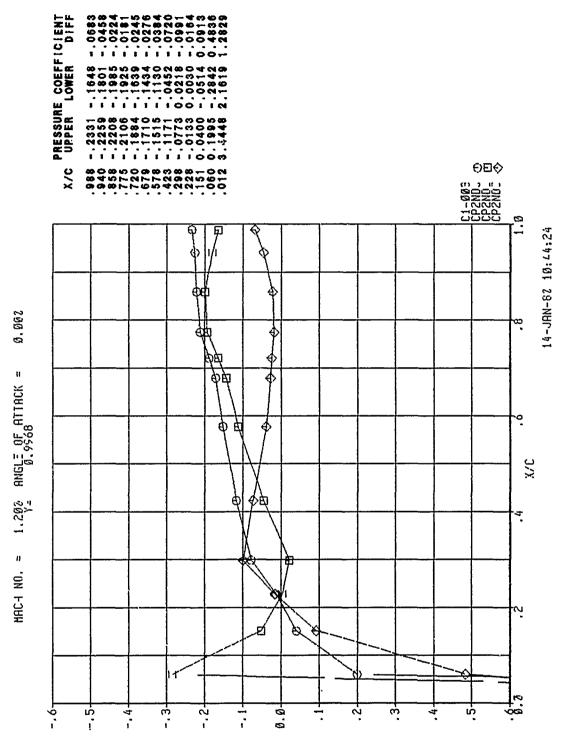


Figure 169, Chordwise Pressure Distribution, Steady, Configuration 1

Cp, pressure coefficient

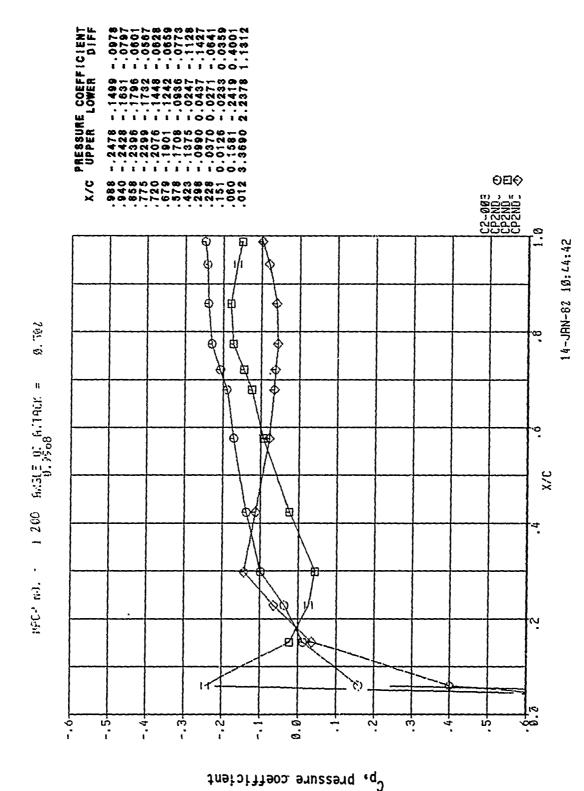


Figure 170, Chordwise Pressure Distribution, Steady, Configuration

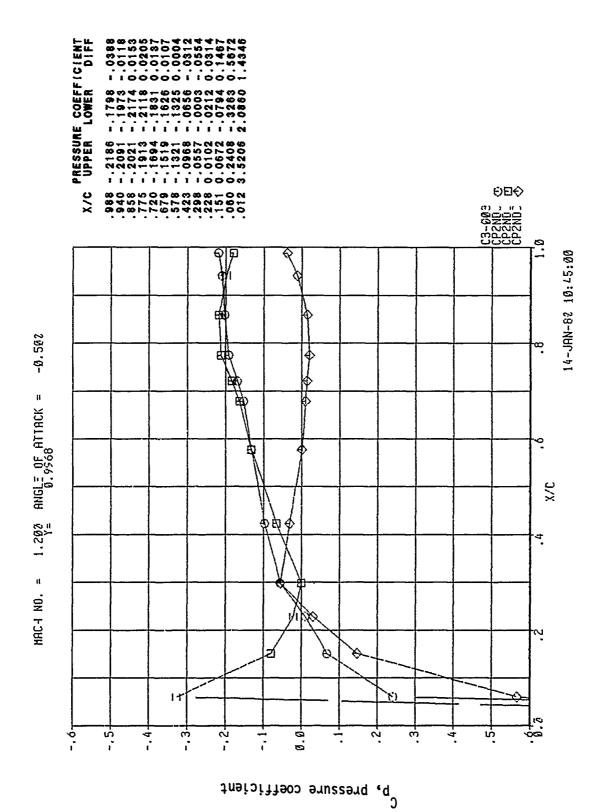
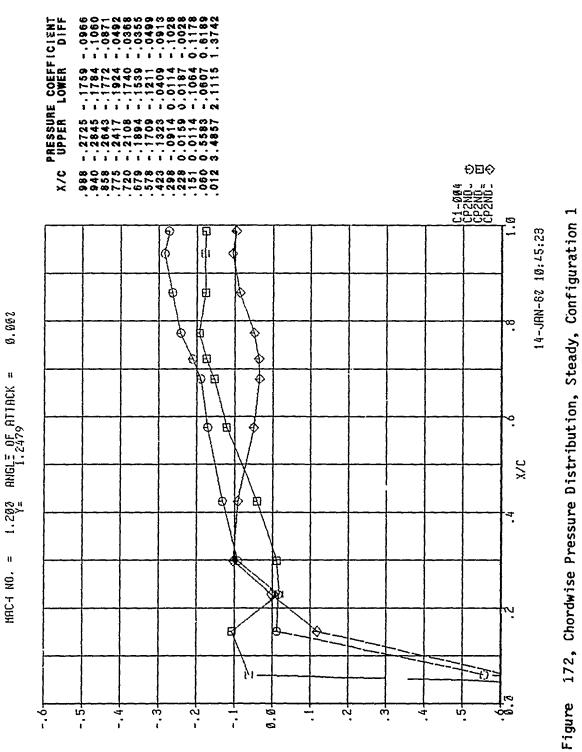


Figure 171, Chordwise Pressure Distribution, Steady, Configuration 1



theisitteos enussend ${}_{cq}$

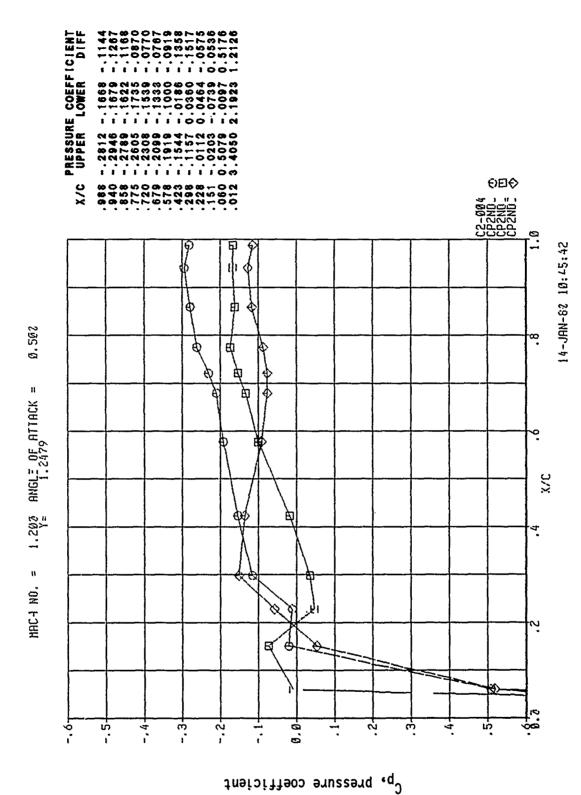
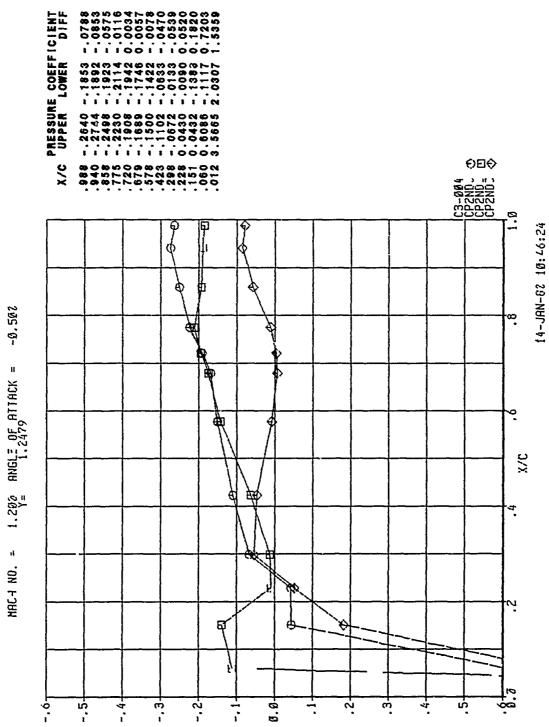
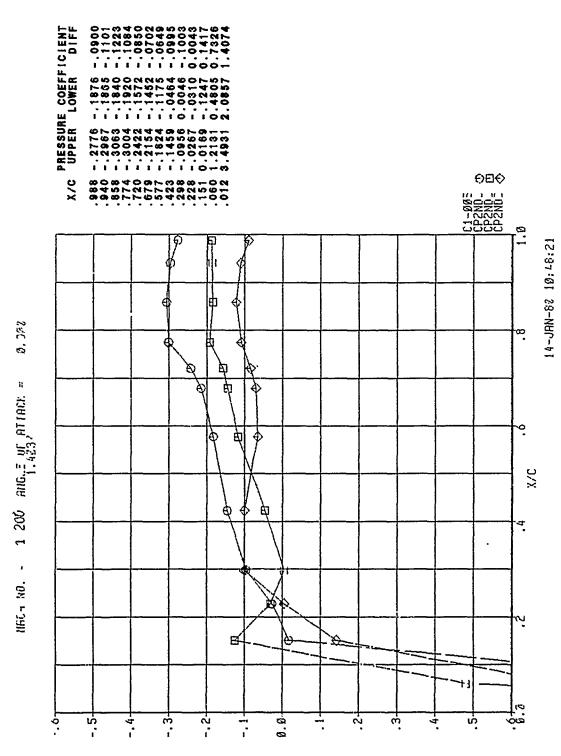


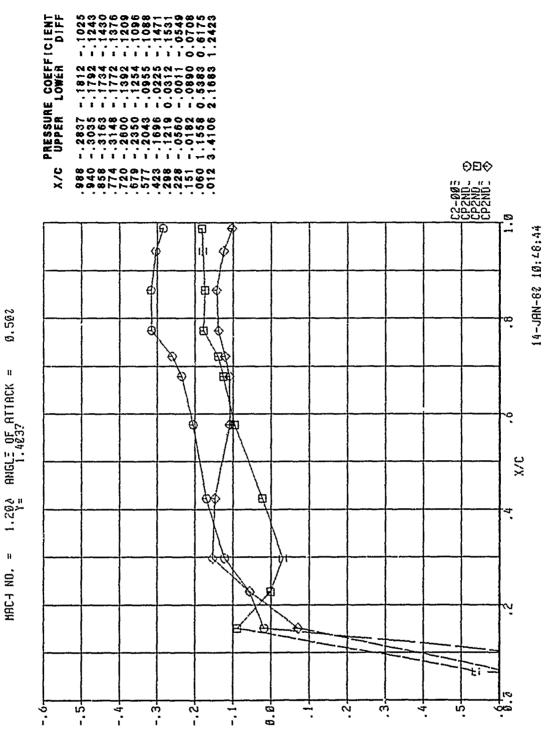
Figure 173, Chordwise Pressure Distribution, Steady, Configuration 1



 $c_{
m p}$, pressure coefficient



175, Chordwise Pressure Distribution, Steady, Configuration 1 Figure



ure 176, Chordwise Pressure Distribution, Steady, Configuration 1

 $C_{\rm p}$, pressure coefficient

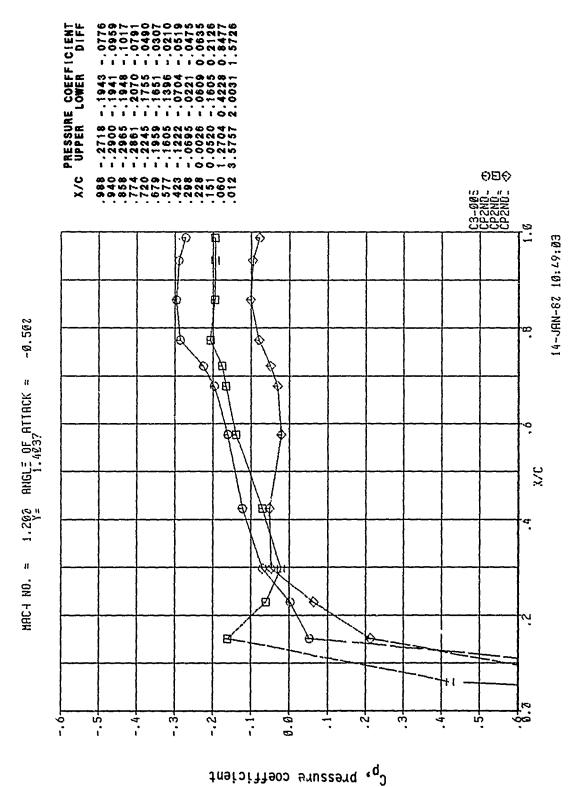
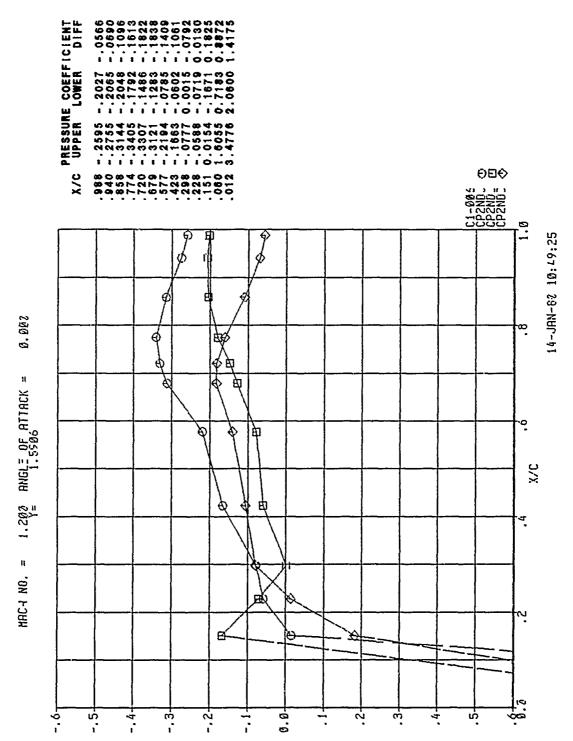
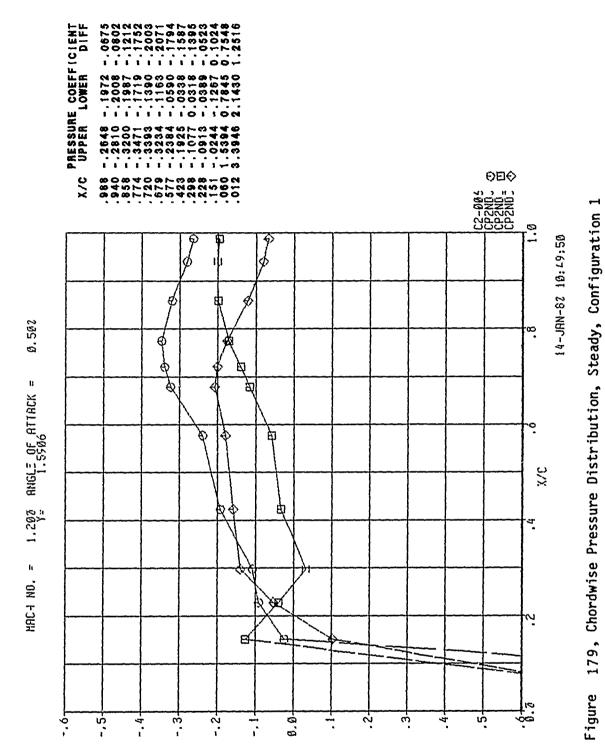


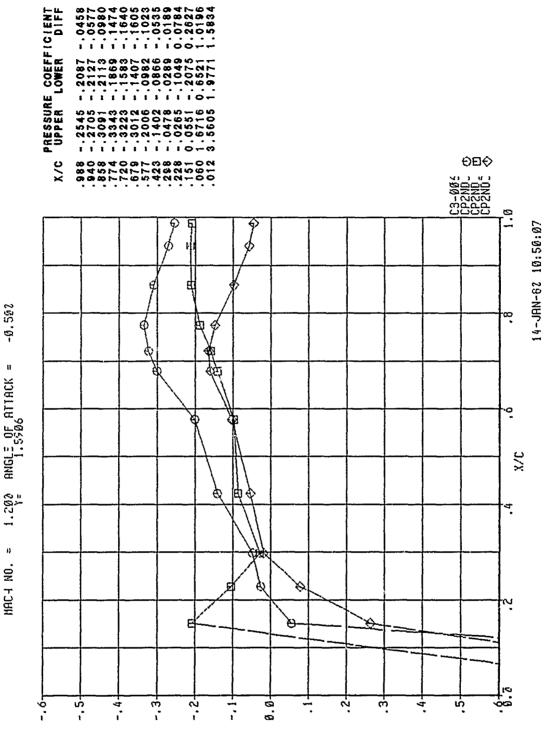
Figure 177, Chordwise Pressure Distribution, Steady, Configuration 1



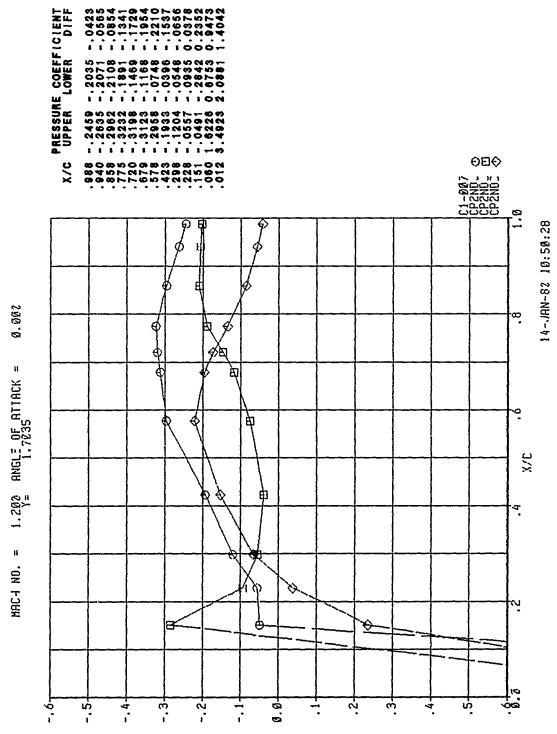
 $\sigma_{\rm p}$, pressure coefficient



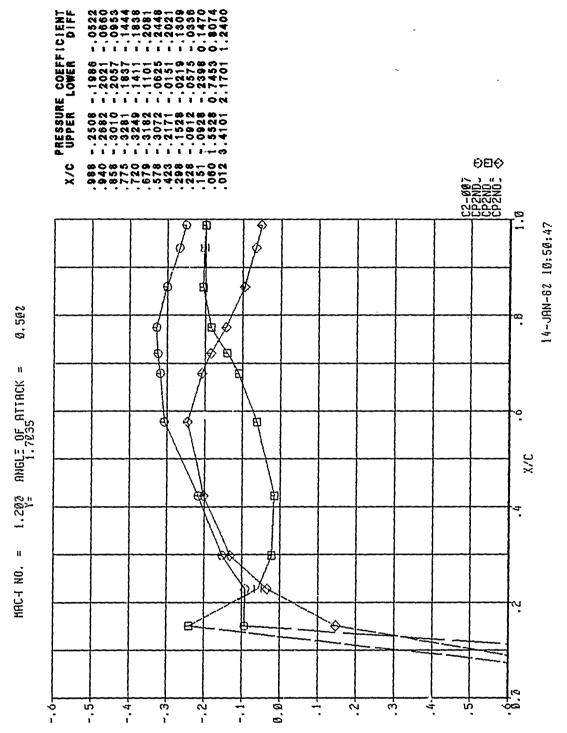
C_p, pressure coefficient



 $\sigma_{\rm p}$, pressure coefficient



C_p, pressure coefficient



 $c_{
m p}$, pressure coefficient

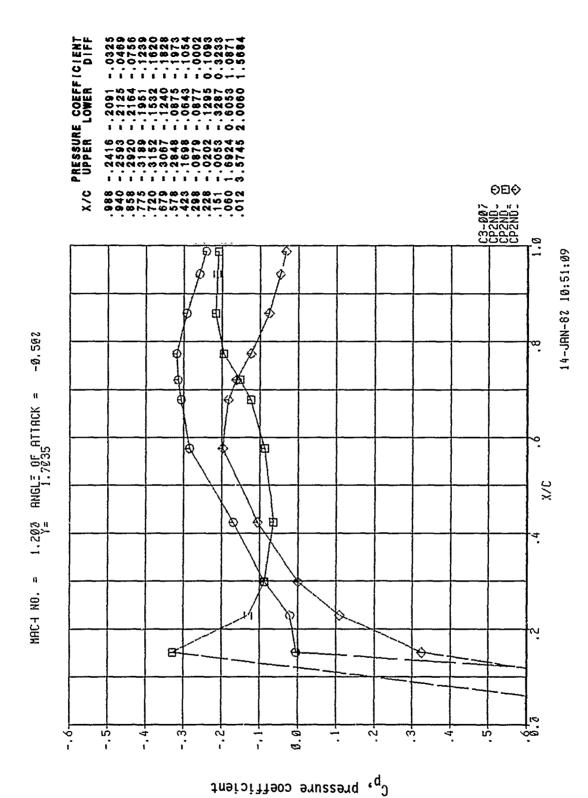
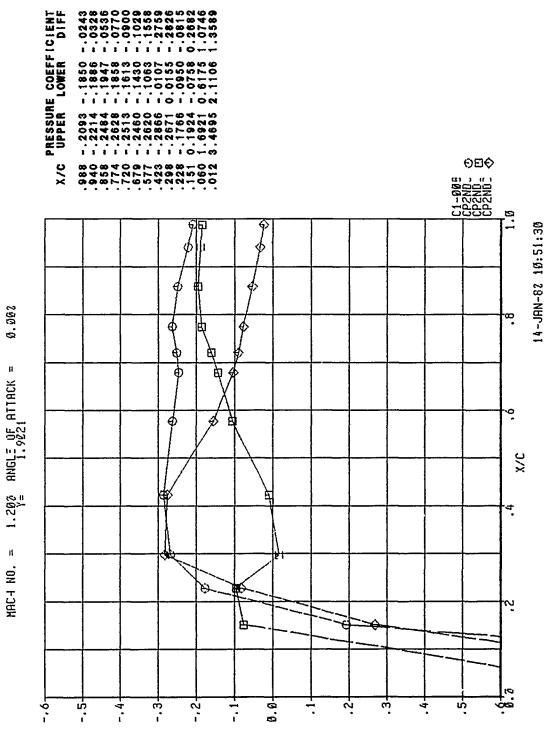


Figure 183, Chordwise Pressure Distribution, Steady, Configuration 1



 $\sigma_{\rm p}$ pressure coefficient

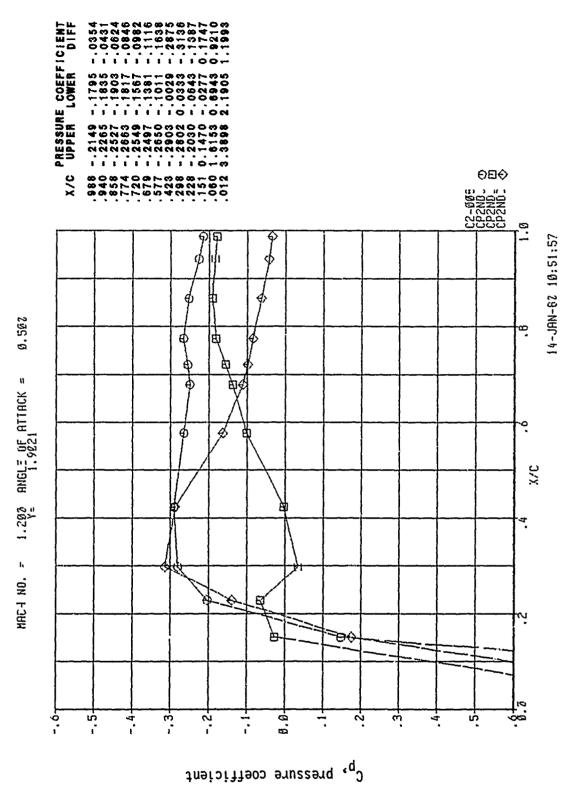
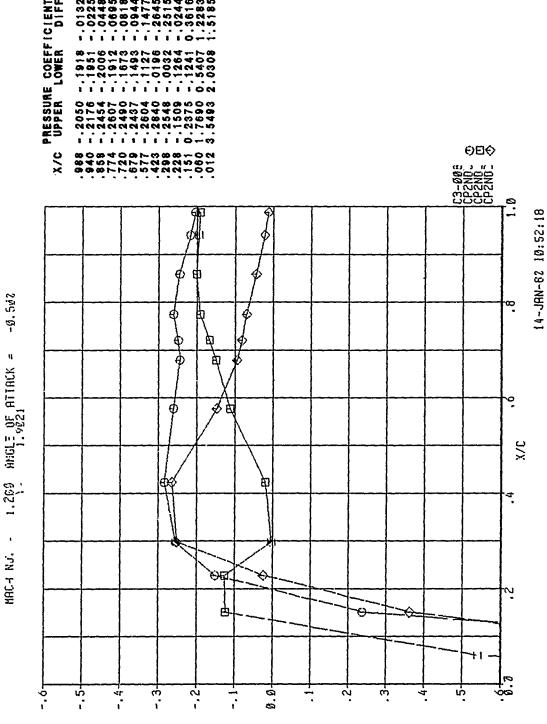
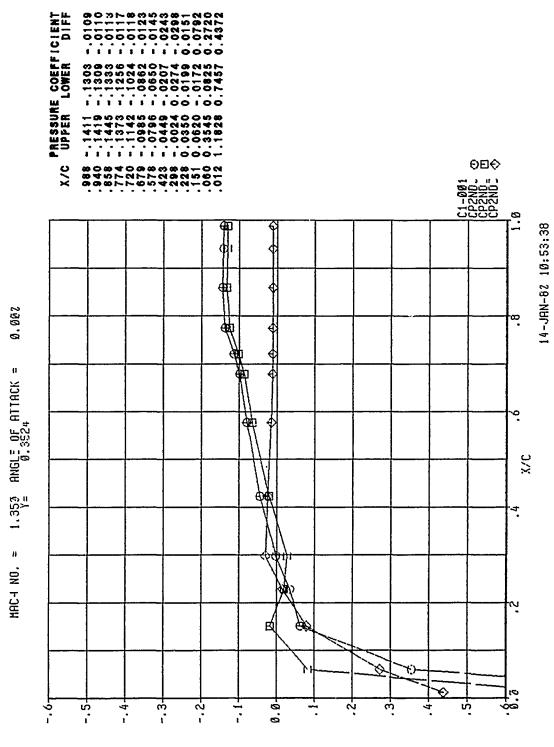


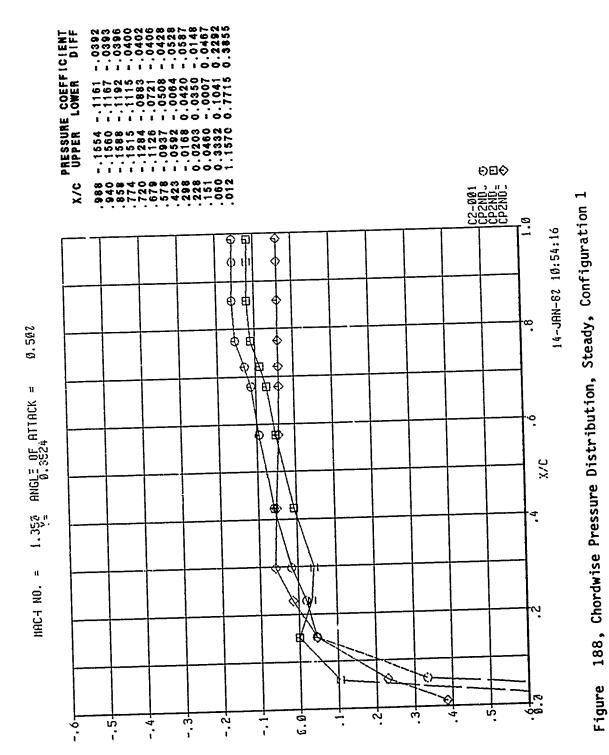
Figure 185, Chordwise Pressure Distribution, Steady, Configuration



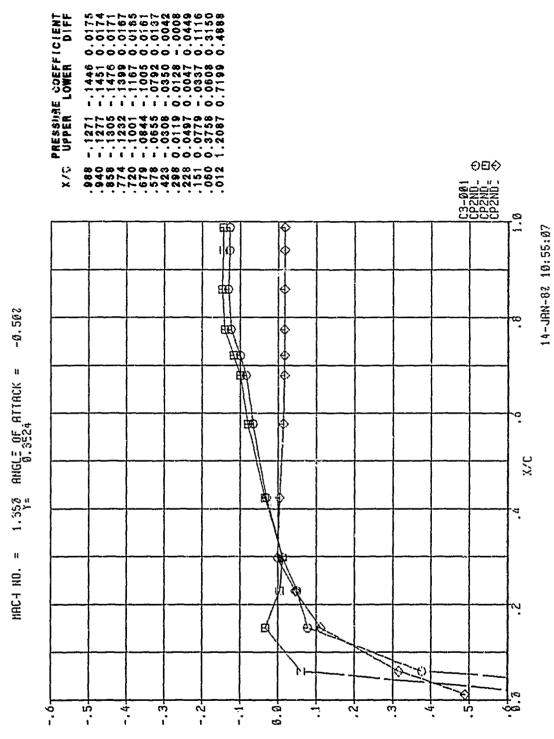
C_p, pressure coefficient



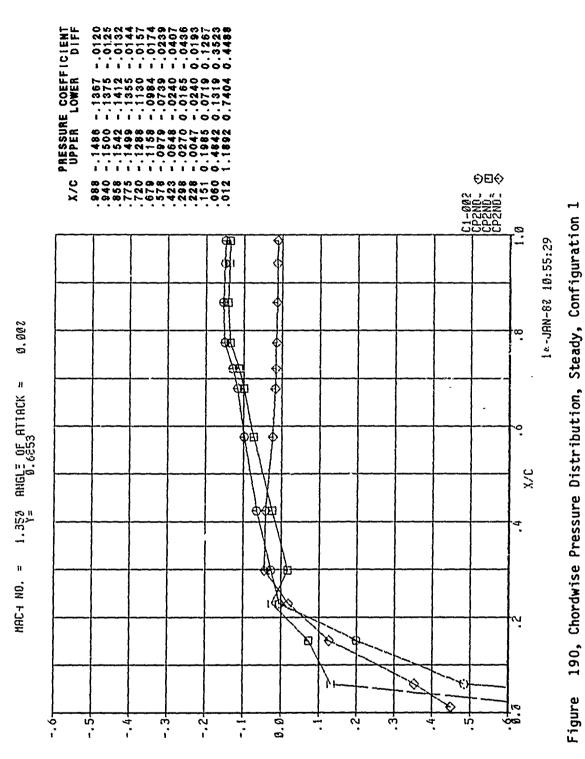
 $c_{
m p}$, pressure coefficient



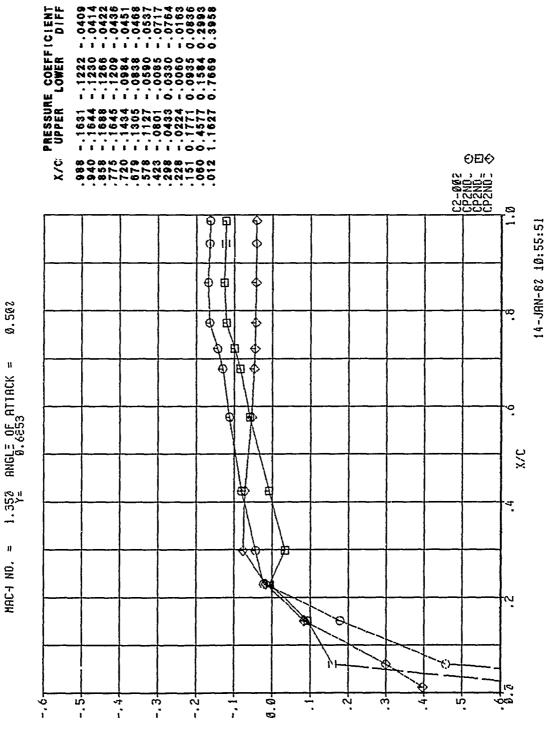
 $C_{\mathbf{p}}$, pressure coefficient



 $C_{\mathbf{p}}$, pressure coefficient



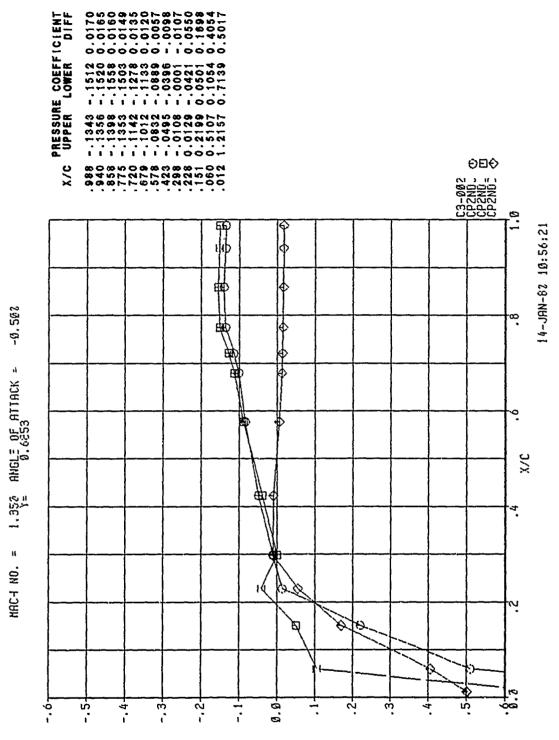
 $C_{\rm p}$, pressure coefficient



 $\sigma_{\rm p}$, pressure coefficient

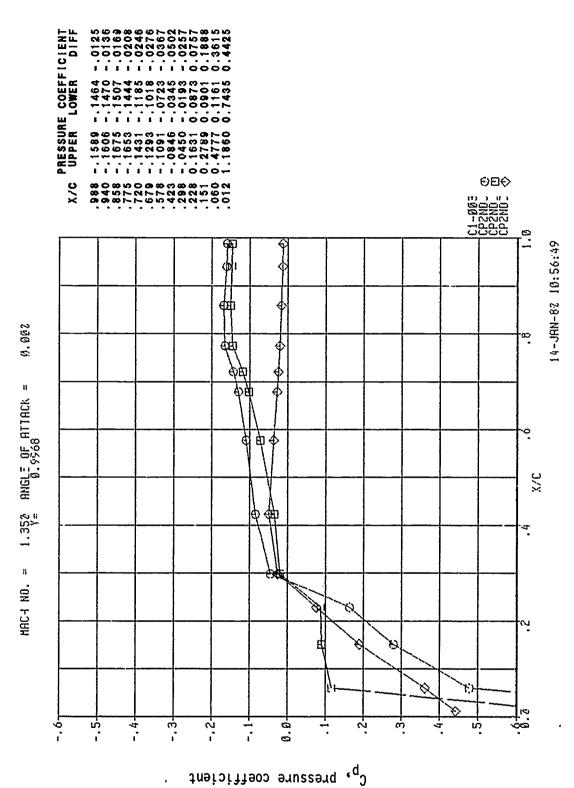
11

MACH NO.



1

Figure 192, Chordwise Pressure Distribution, Steady, Configuration



193, Chordwise Pressure Distribution, Steady, Configuration Figure

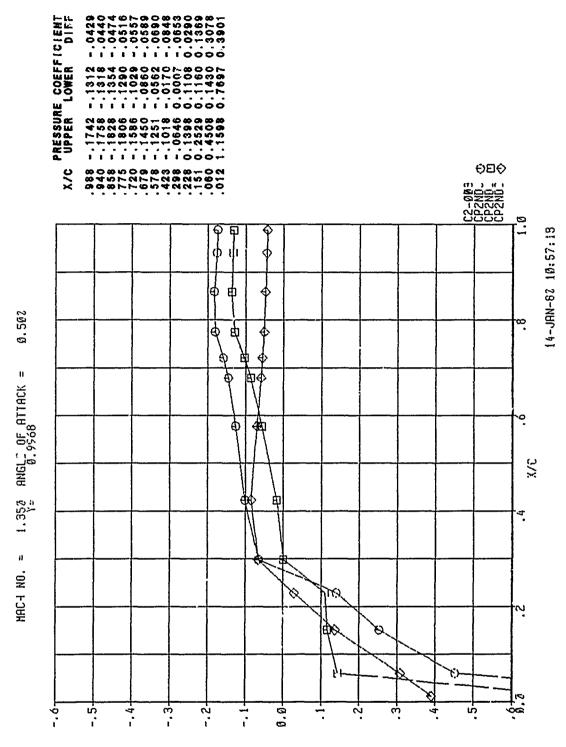


Figure 194, Chordwise Pressure Distribution, Steady, Configuration

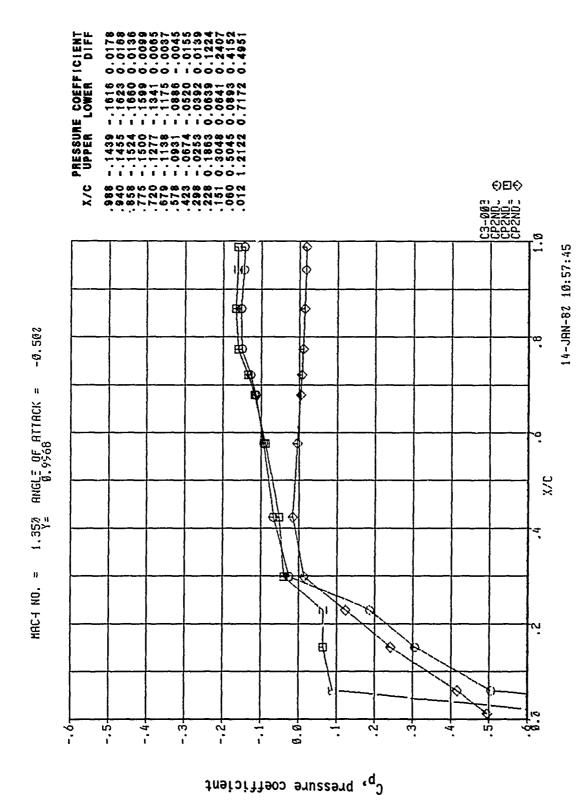


Figure 195, Chordwise Pressure Distribution, Steady, Configuration

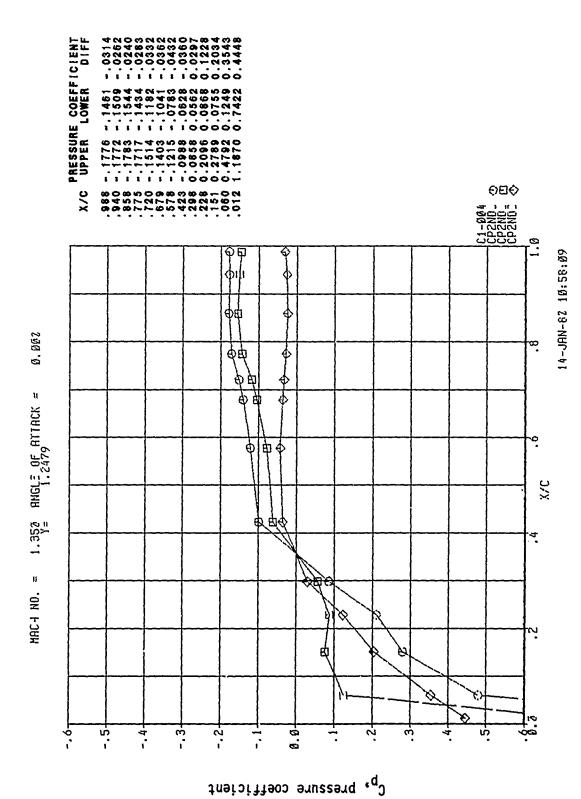
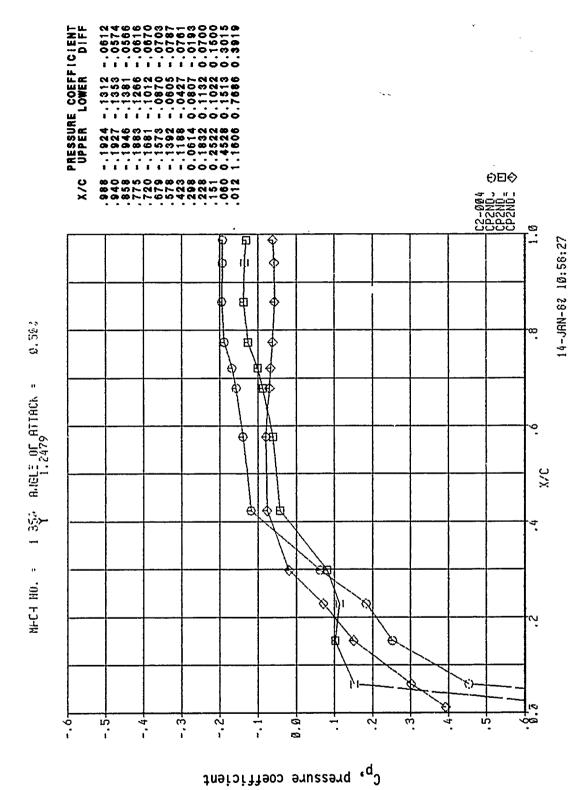
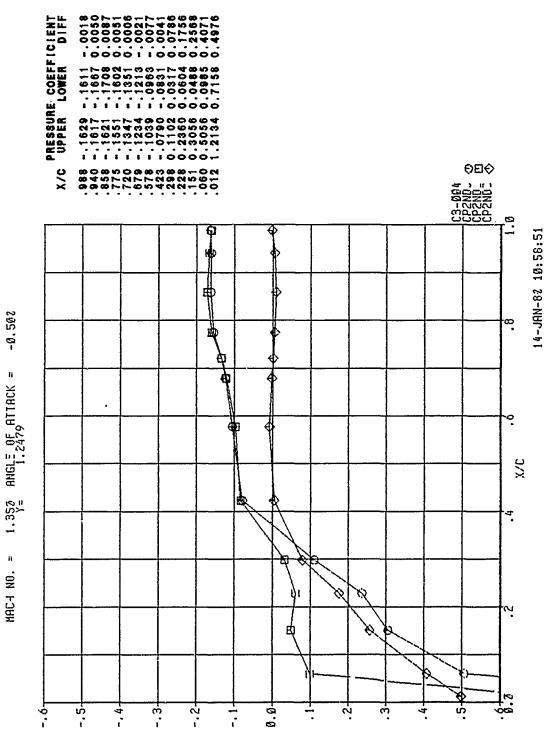


Figure 196, Chordwise Pressure Distribution, Steady, Configuration 1



197, Chordwise Pressure Distribution, Steady, Configuration



C_p, pressure coefficient

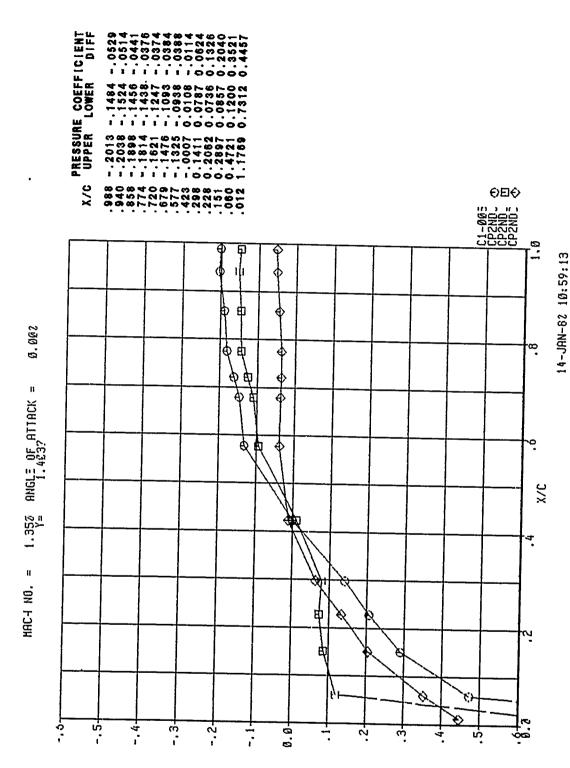
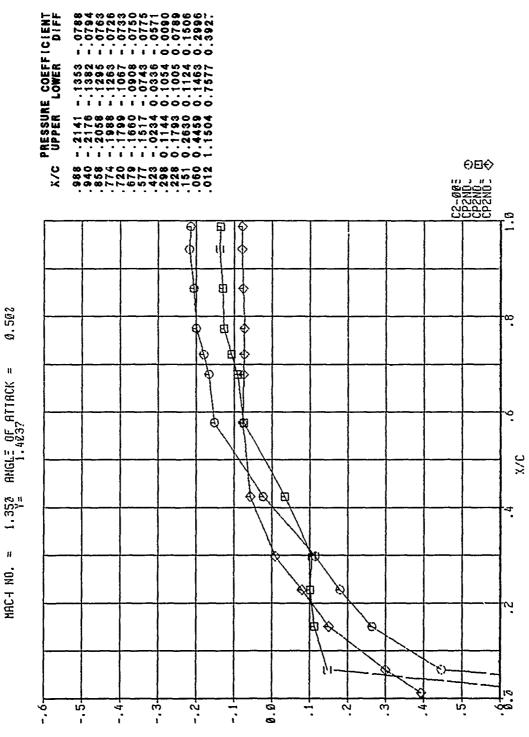
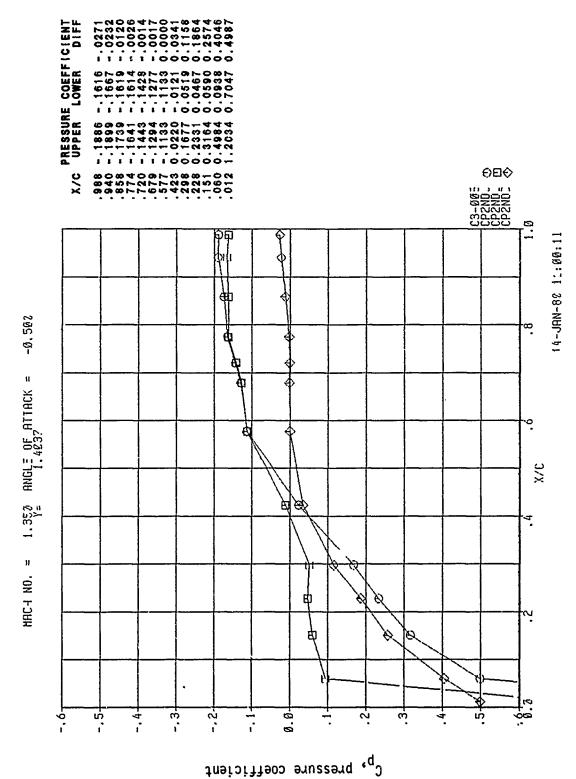


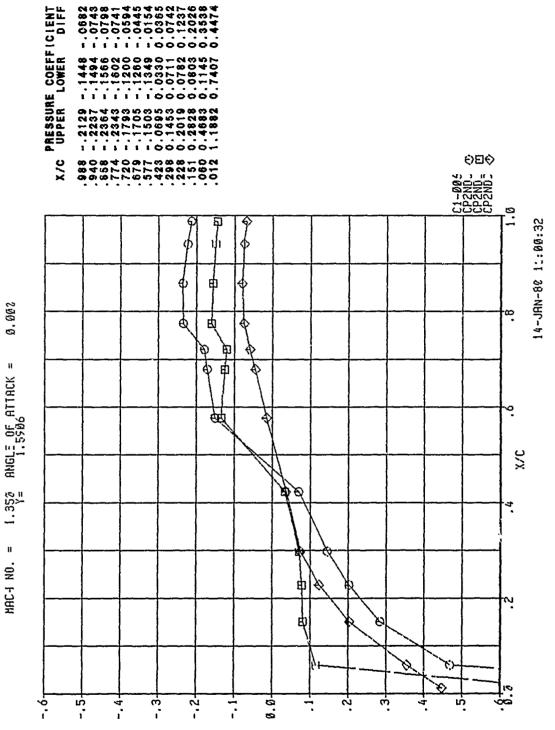
Figure 199, Chordwise Pressure Distribution, Steady, Configuration



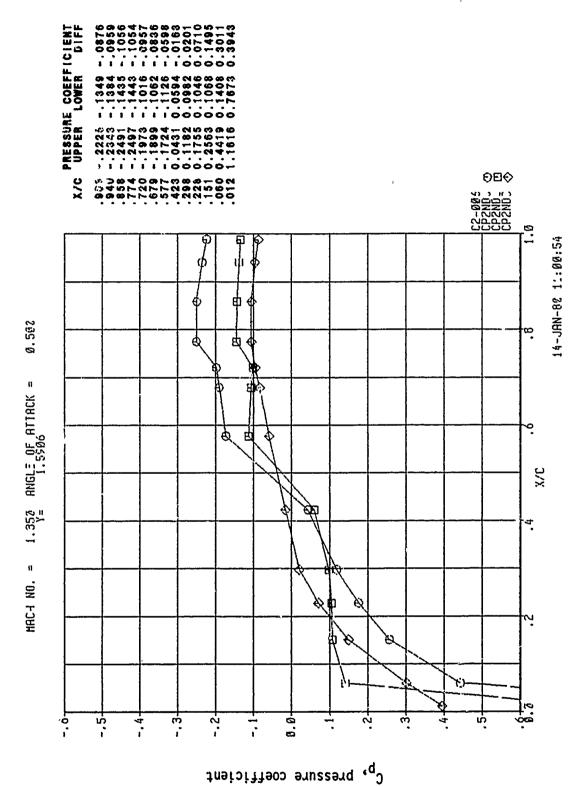
The state coefficient q_0



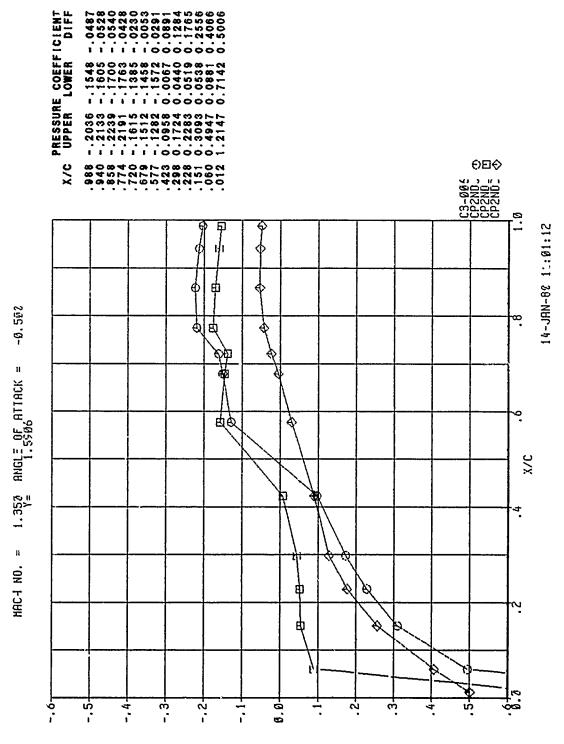
201, Chordwise Pressure Distribution, Steady, Configuration 1 Figure



ure 202, Chordwise Pressure Distribution, Steady, Configuration 1

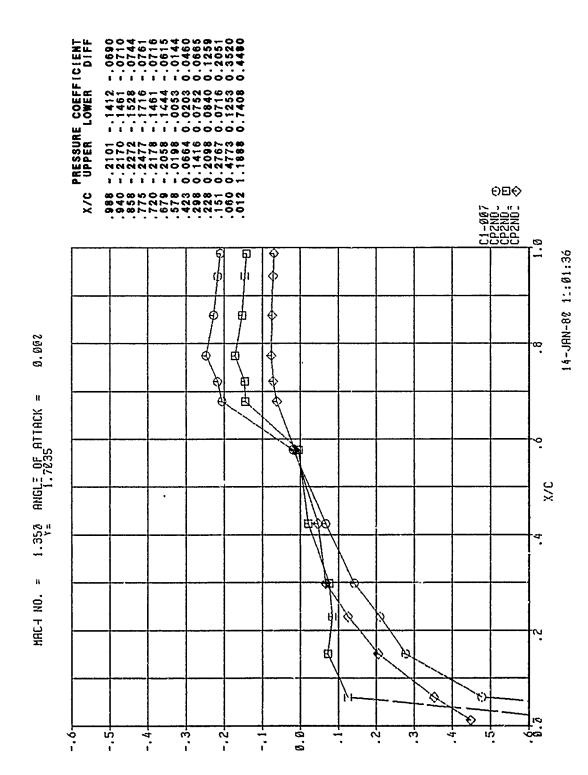


203, Chordwise Pressure Distribution, Steady, Configuration 1 Figure



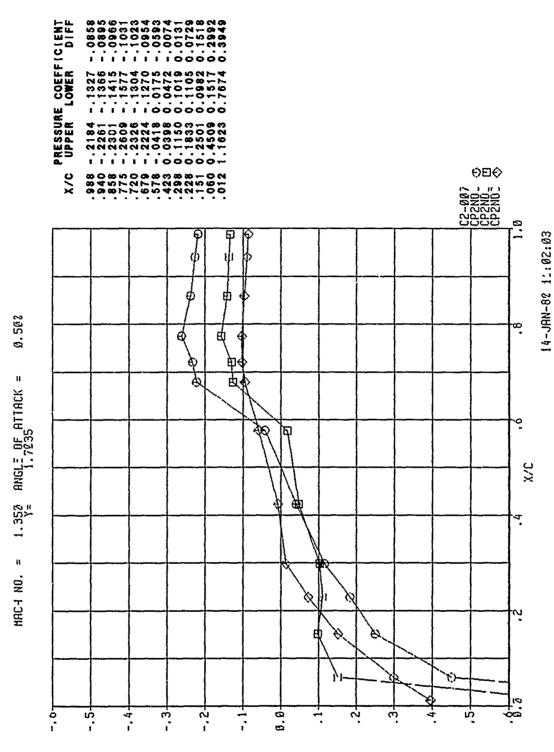
ure 204, Chordwise Pressure Distribution, Steady, Configuration

 σ_{p} , pressure coefficient



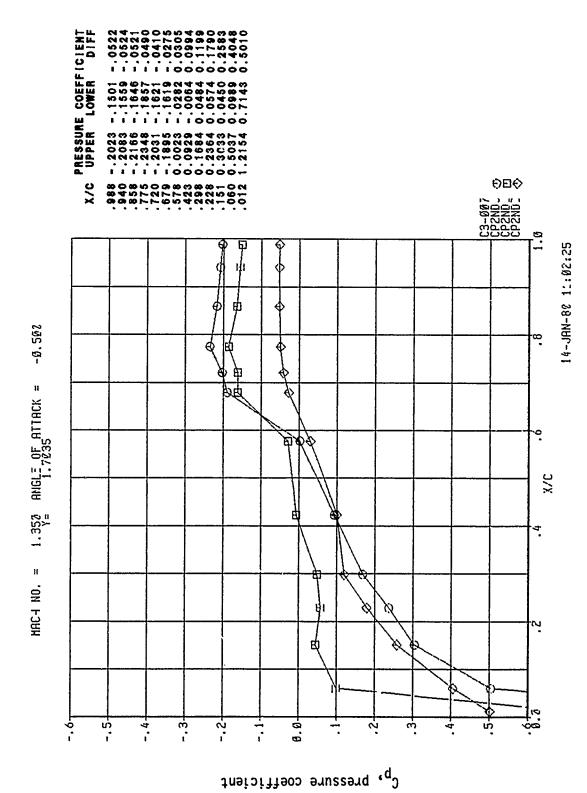
205, Chordwise Pressure Distribution, Steady, Configuration Figure

Up, pressure coefficient $^{\prime}_{\rm p}$

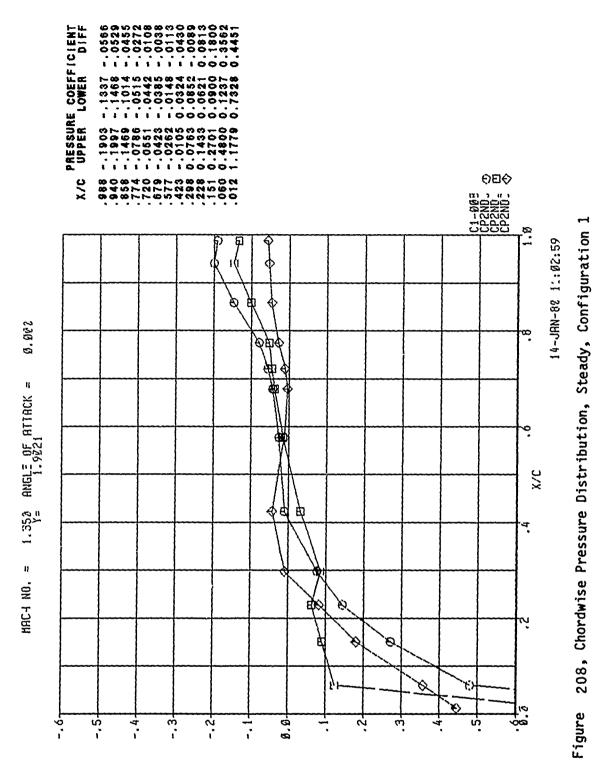


206, Chordwise Pressure Distribution, Steady, Configuration 1

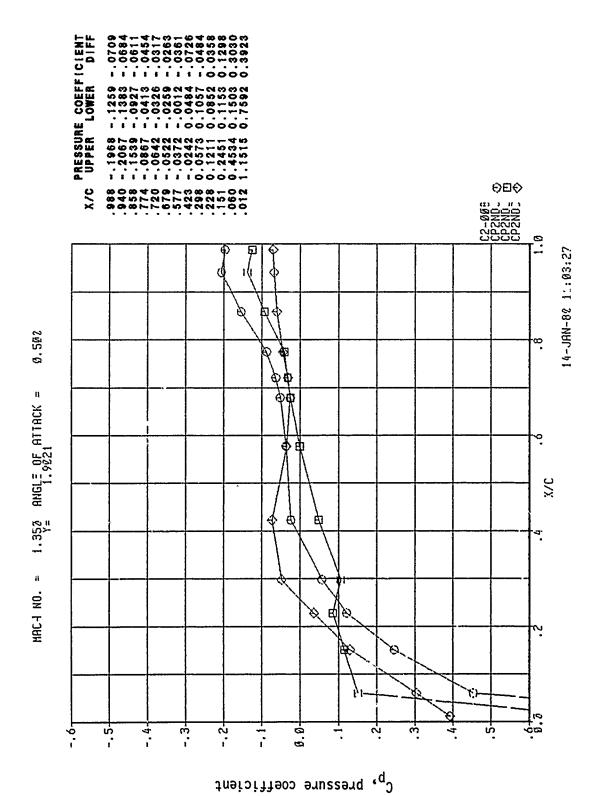
 $\sigma_{\rm p}$, pressure coefficient



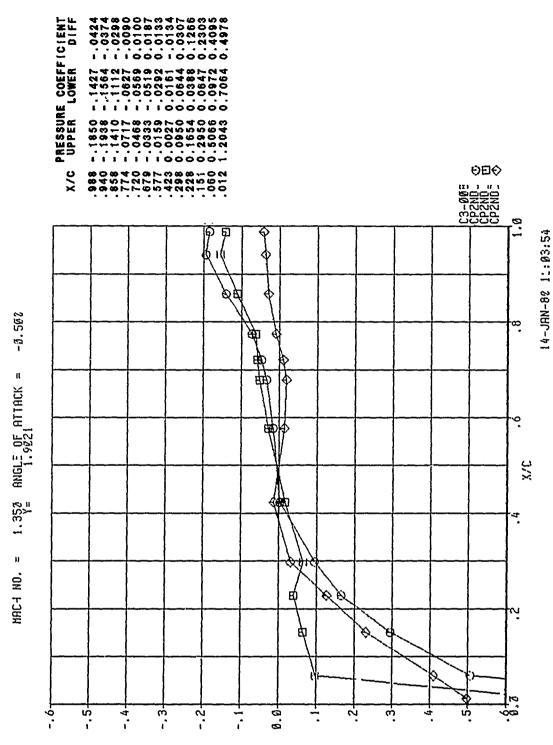
207, Chordwise Pressure Distribution, Steady, Configuration Figure



Cp, pressure coefficient



209, Chordwise Pressure Distribution, Steady, Configuration Figure



210, Chordwise Pressure Distribution, Steady, Configuration

 $C_{\mathbf{p}}$, pressure coefficient

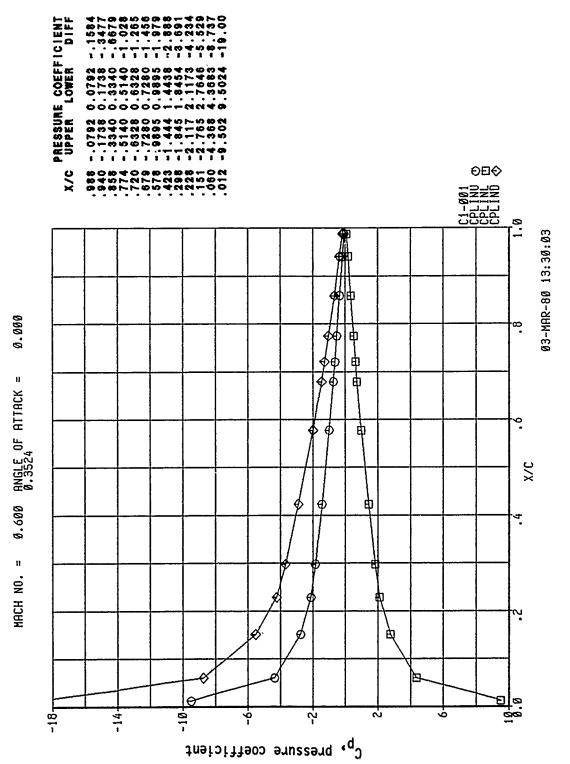


Figure 211, Chordwise Pressure Distribution, Real, Configuration 1

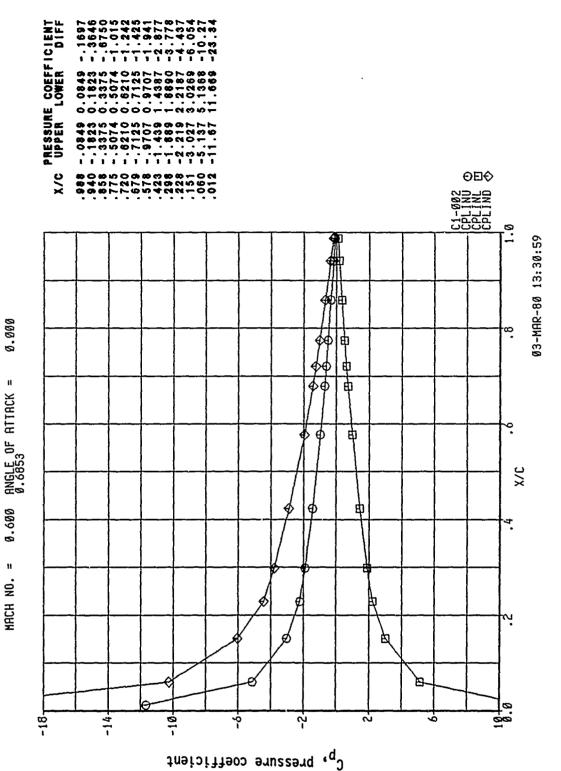


Figure 212, Chordwise Pressure Distribution, Real, Configuration 1

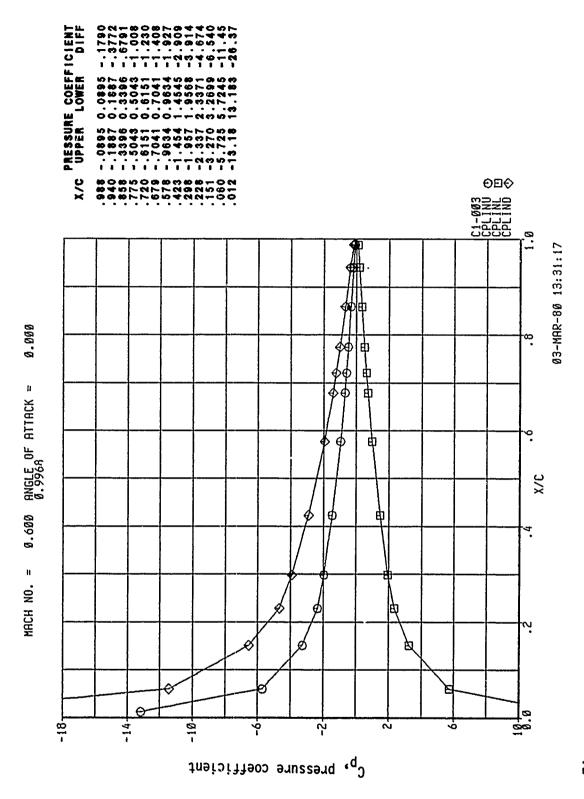


Figure 213, Chordwise Pressure Distribution, Real, Configuration

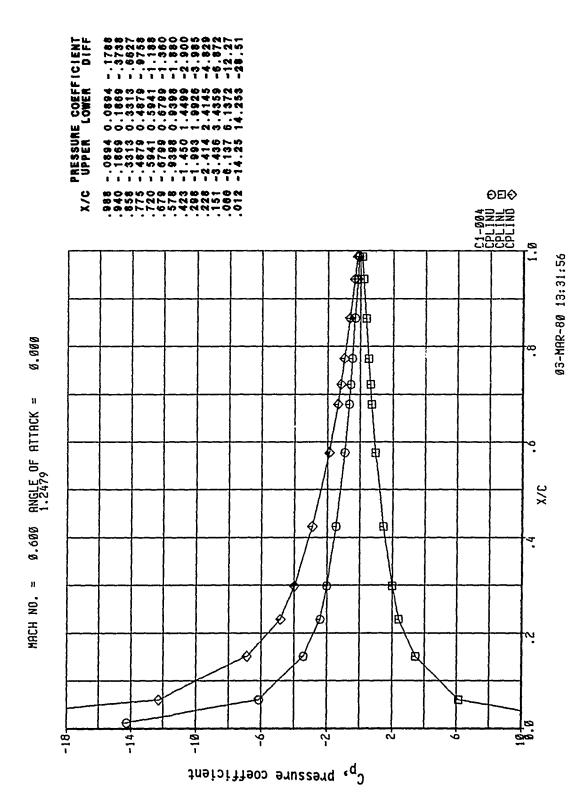


Figure 214, Chordwise Pressure Distribution, Real, Configuration 1

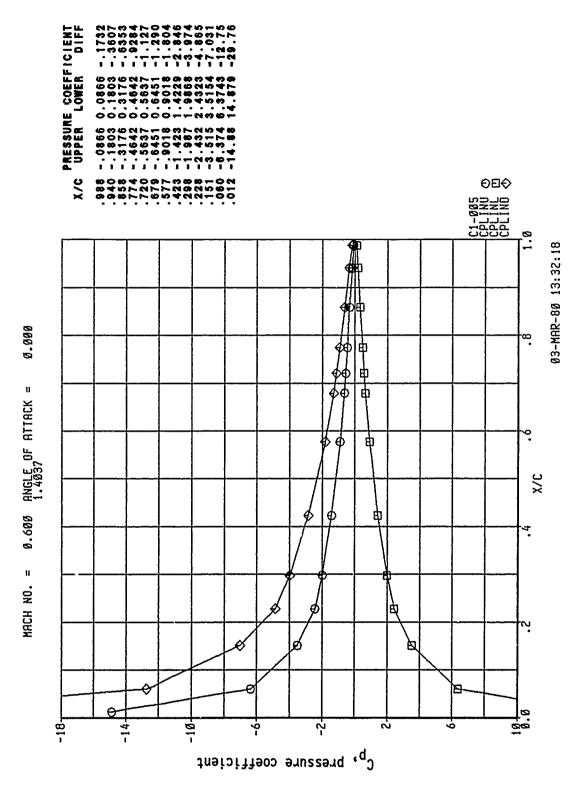


Figure 215, Chordwise Pressure Distribution, Real, Configuration 1

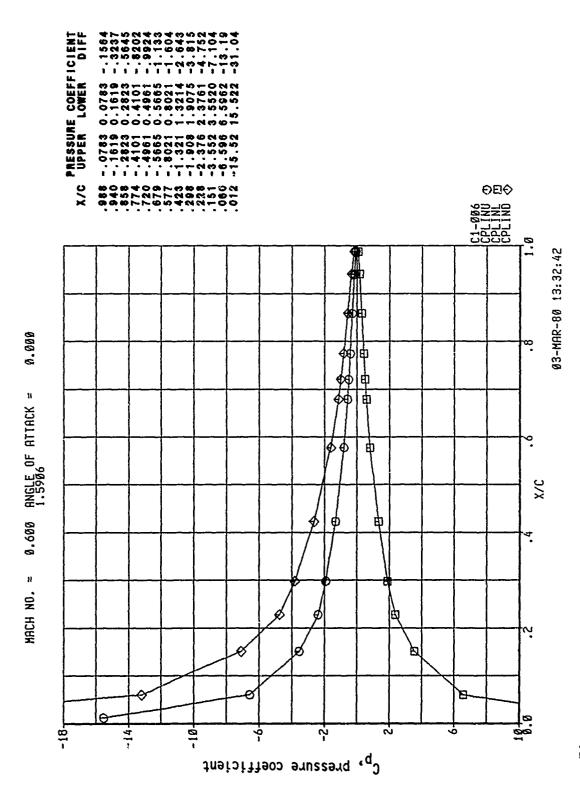


Figure 216, Chordwise Pressure Distribution, Real, Configuration 1

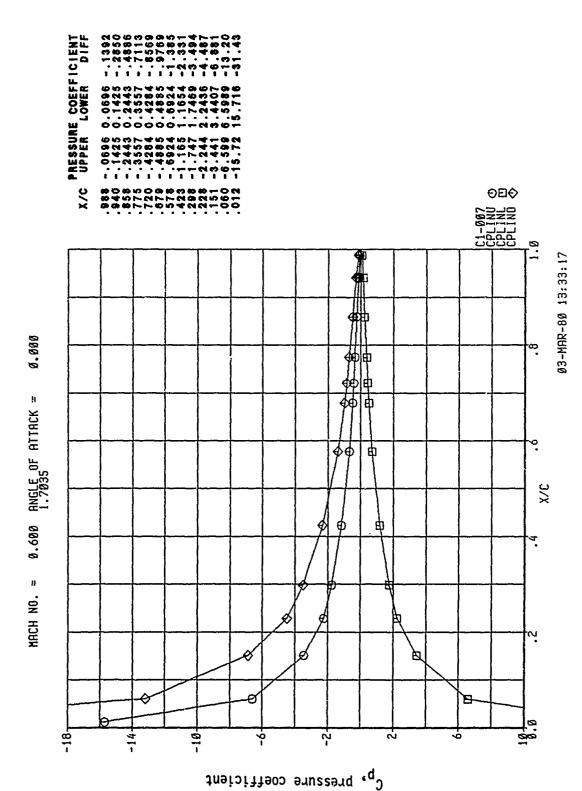
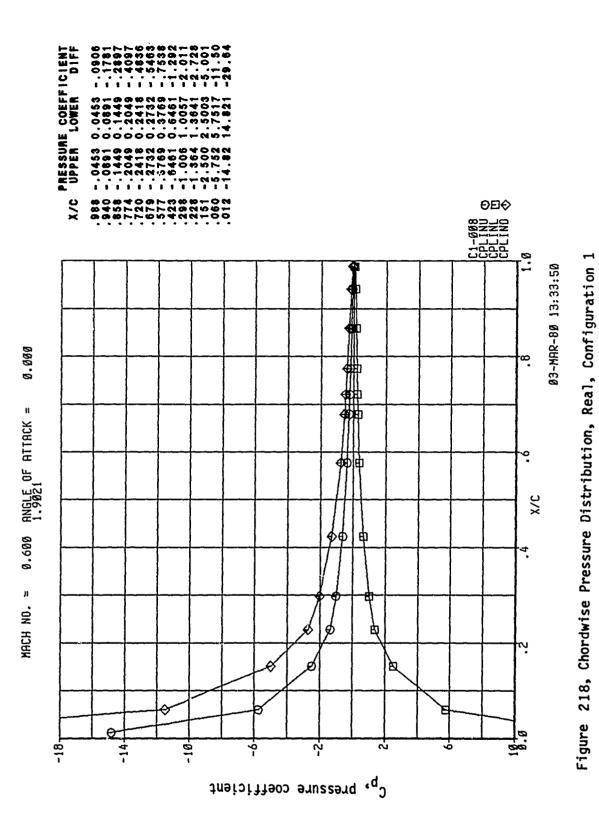


Figure 217, Chordwise Pressure Distribution, Real, Configuration 1



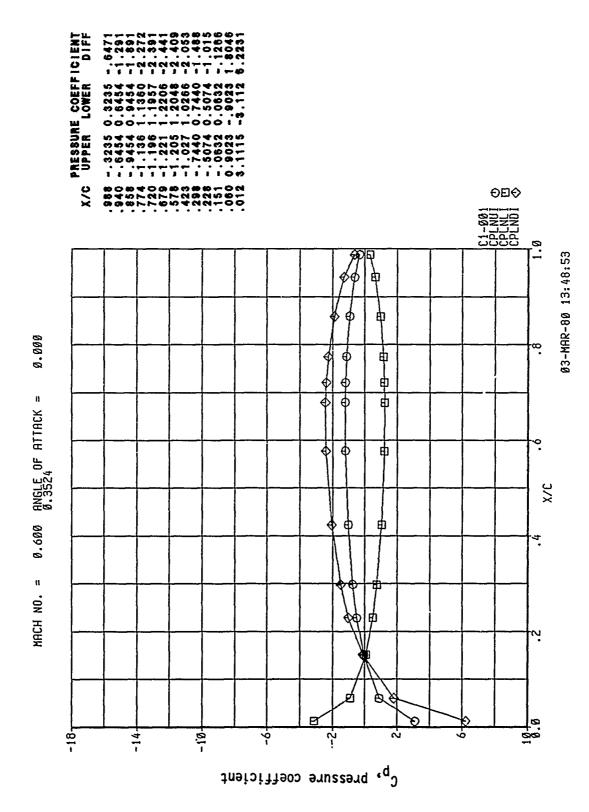


Figure 219, Chordwise Pressure Distribution, Imaginary, Configuration 1

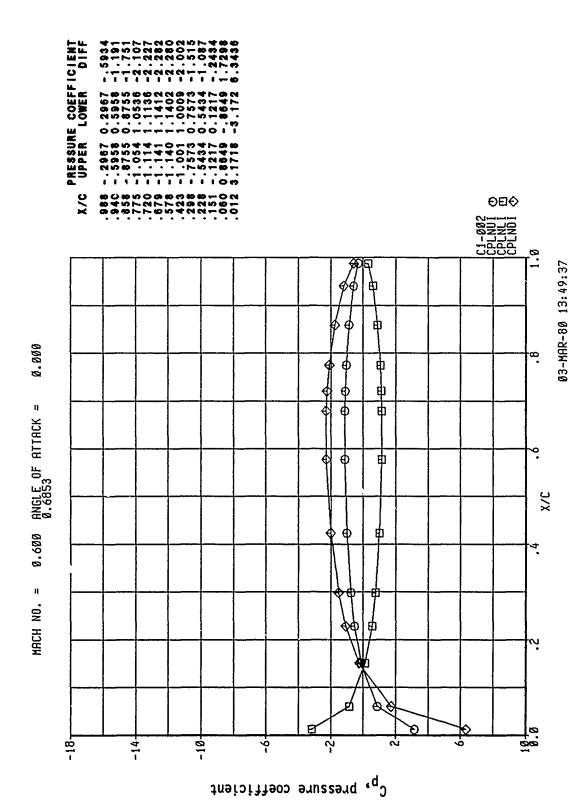


Figure 220, Chordwise Pressure Distribution, Imaginary, Configuration 1

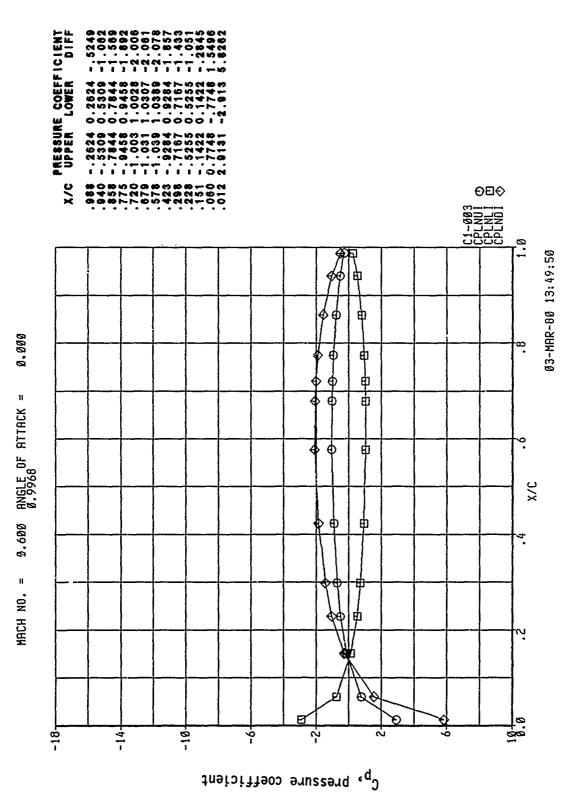


Figure 221, Chordwise Pressure Distribution, Imaginary, Configuration

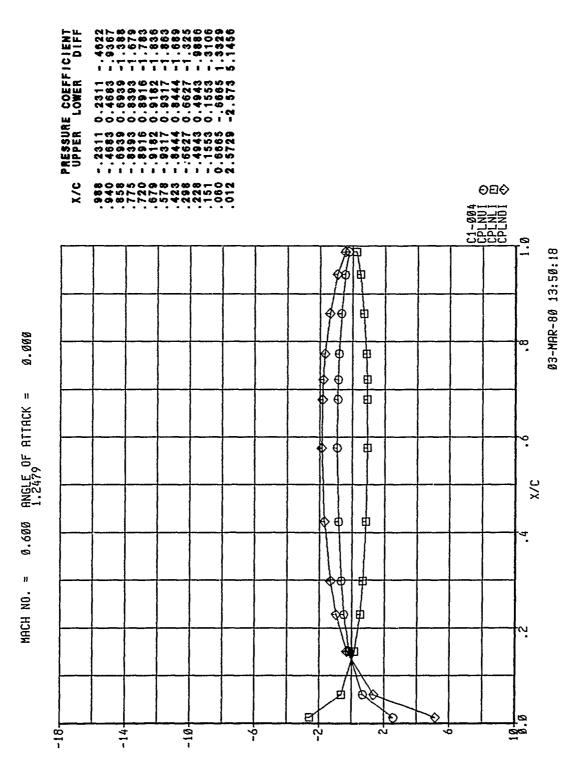


Figure 222, Chordwise Pressure Distribution, Imaginary, Configuration 1

 $C_{\mathbf{p}}$, pressure coefficient

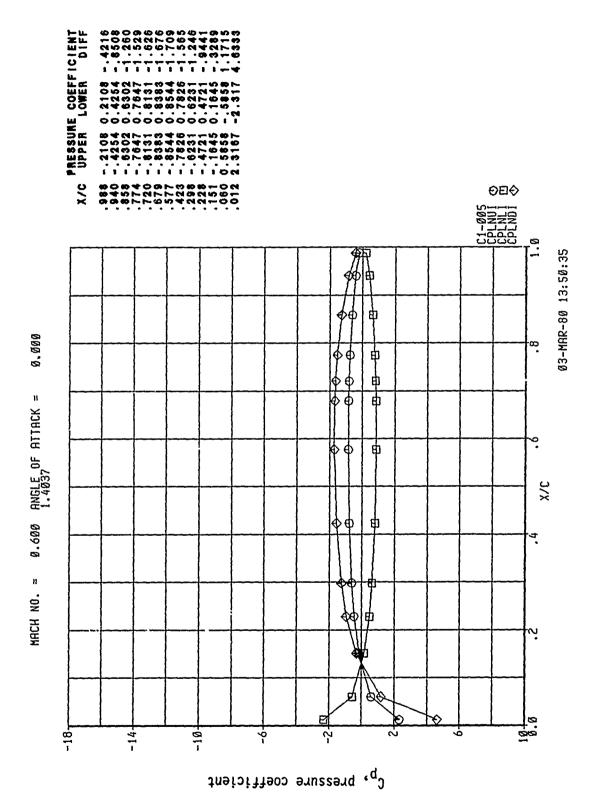


Figure 223, Chordwise Pressure Distribution, Imaginary, Configuration 1

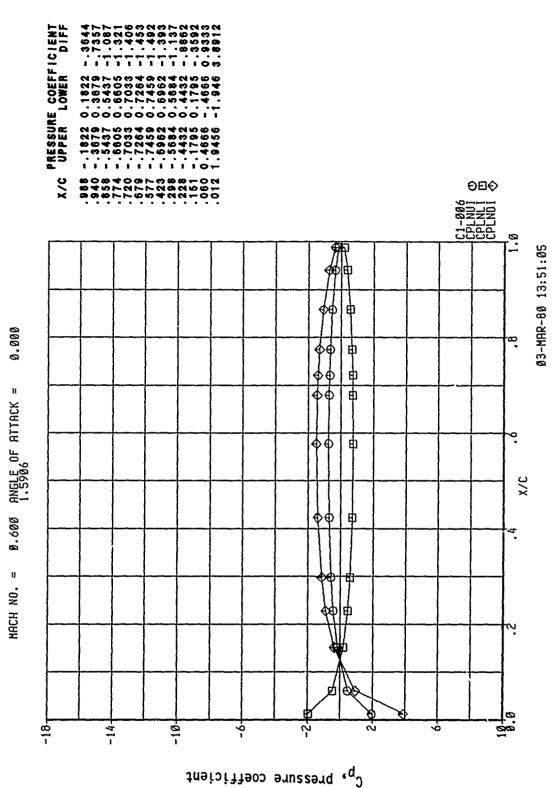


Figure 224, Chordwise Pressure Distribution, Imaginary, Configuration 1

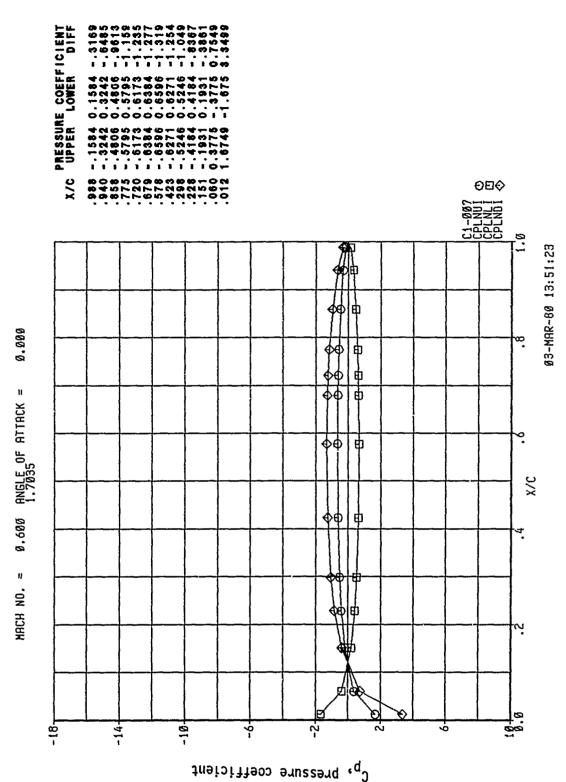


Figure 225, Chordwise Pressure Distribution, Imaginary, Configuration

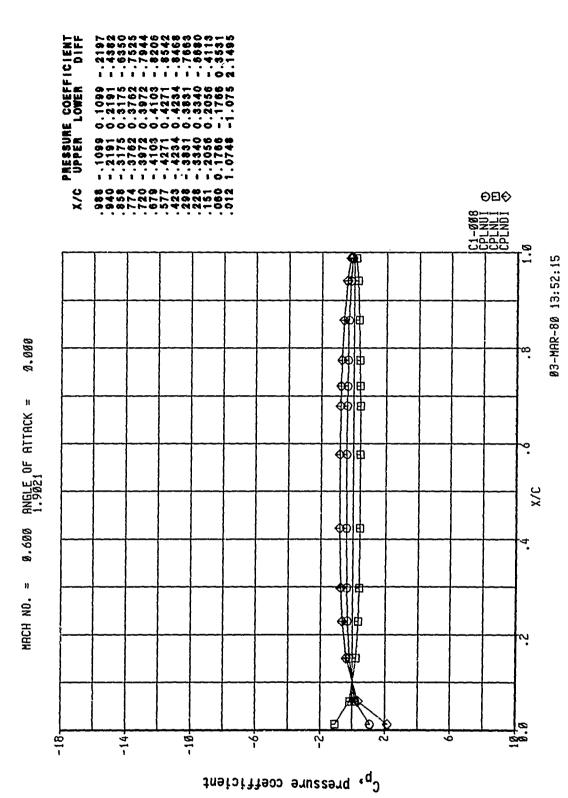


Figure 226, Chordwise Pressure Distribution, Imaginary, Configuration

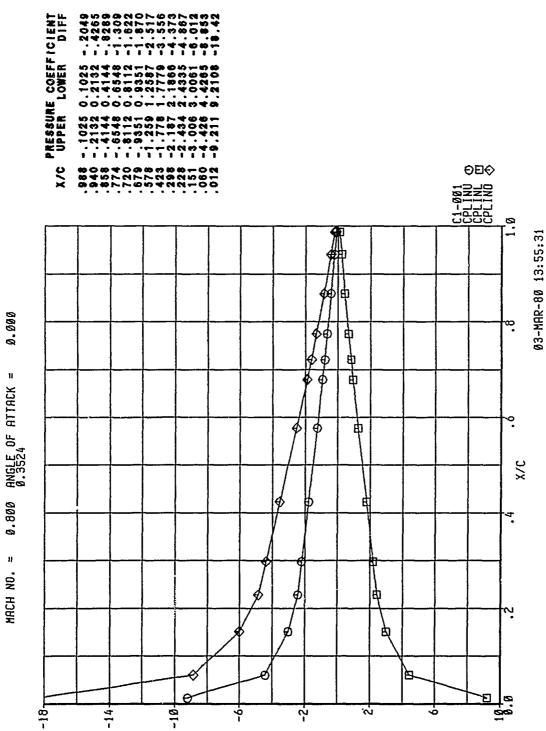


Figure 227, Chordwise Pressure Distribution, Real, Configuration 1

 $c_{\mathbf{p}}$, pressure coefficient

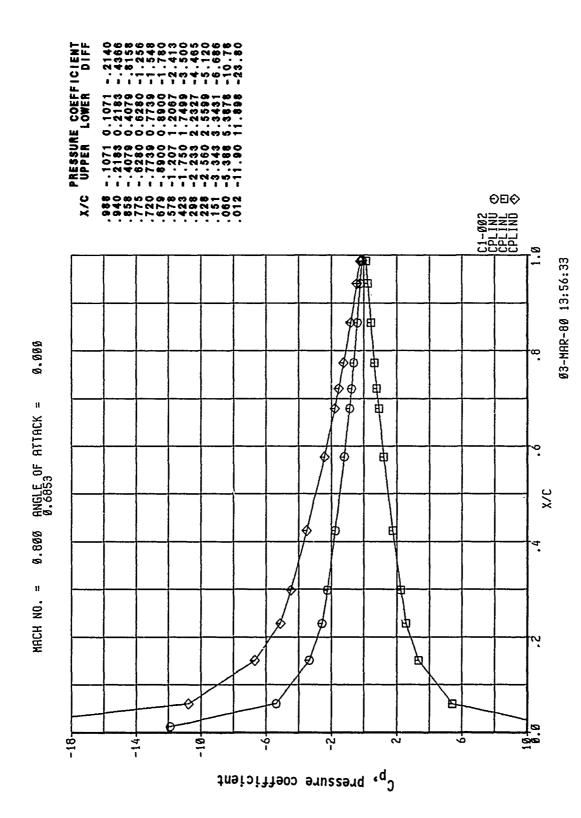


Figure 228, Chordwise Pressure Distribution, Real, Configuration 1

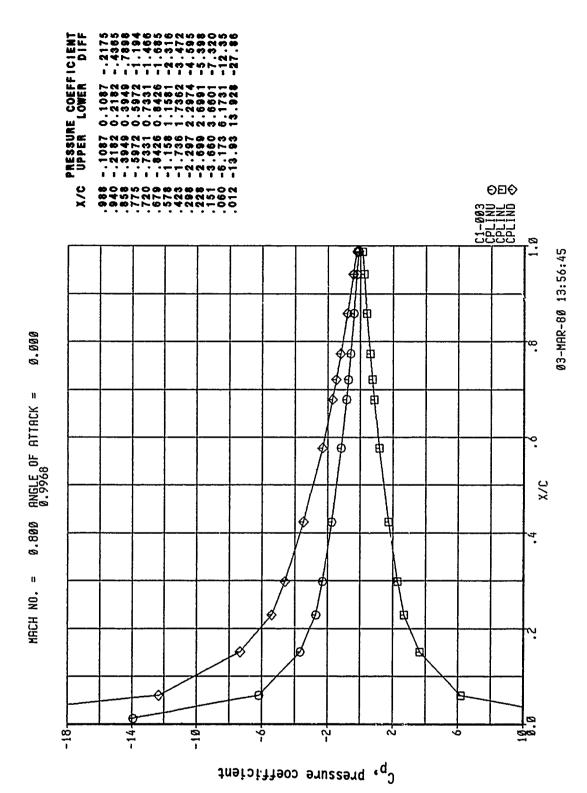


Figure 229, Chordwise Pressure Distribution, Real, Configuration 1

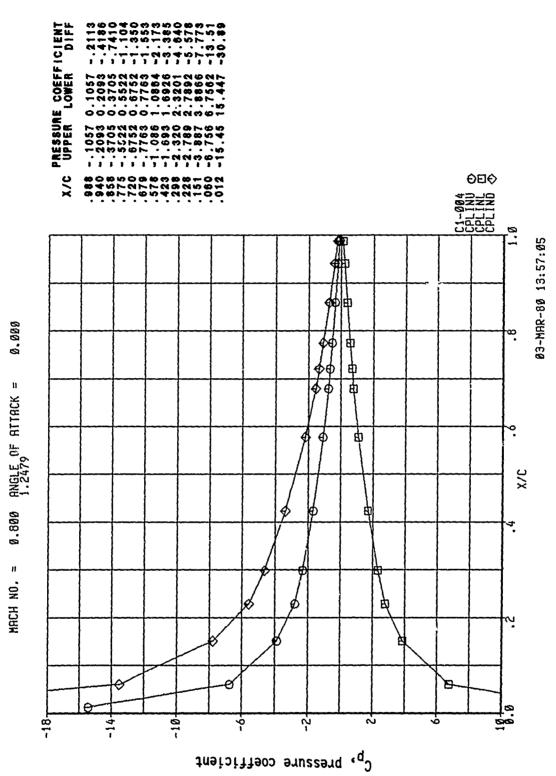


Figure 230, Chordwise Pressure Distribution, Real, Configuration I

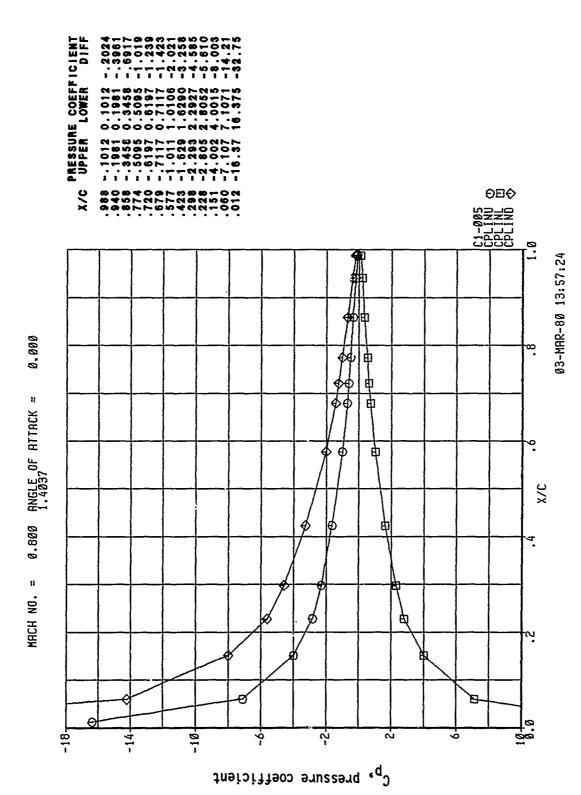
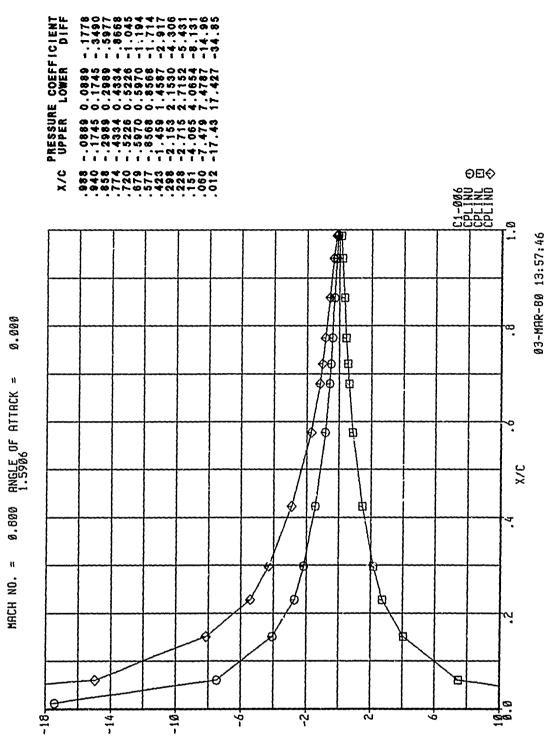


Figure 231, Chordwise Pressure Distribution, Real, Configuration 1



0.000

0.800

Ħ

MACH NO.

Figure 232, Chordwise Pressure Distribution, Real, Configuration 1

 $C_{\mathbf{p}}$, pressure coefficient

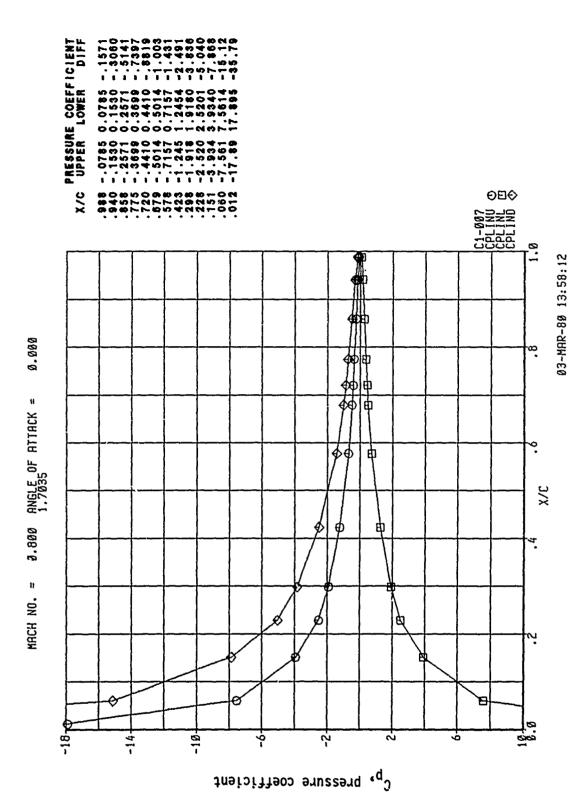


Figure 233, Chordwise Pressure Distribution, Real, Configuration 1

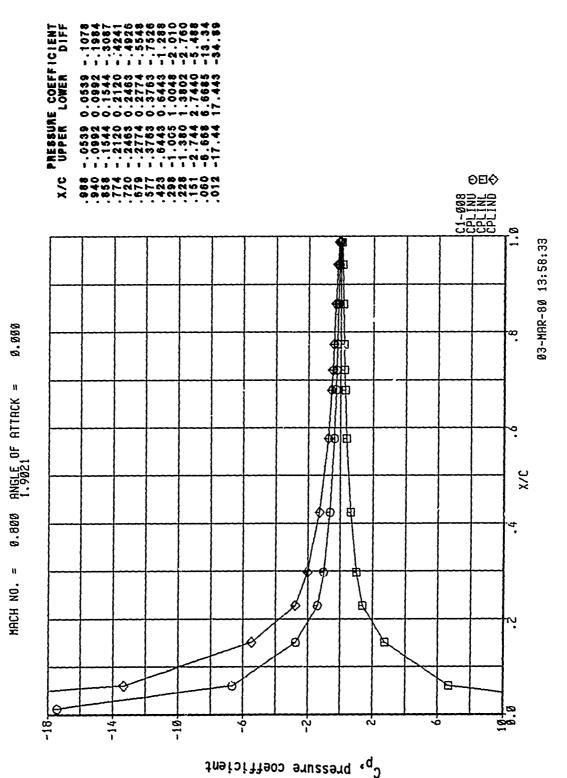


Figure 234, Chordwise Pressure Distribution, Real, Configuration

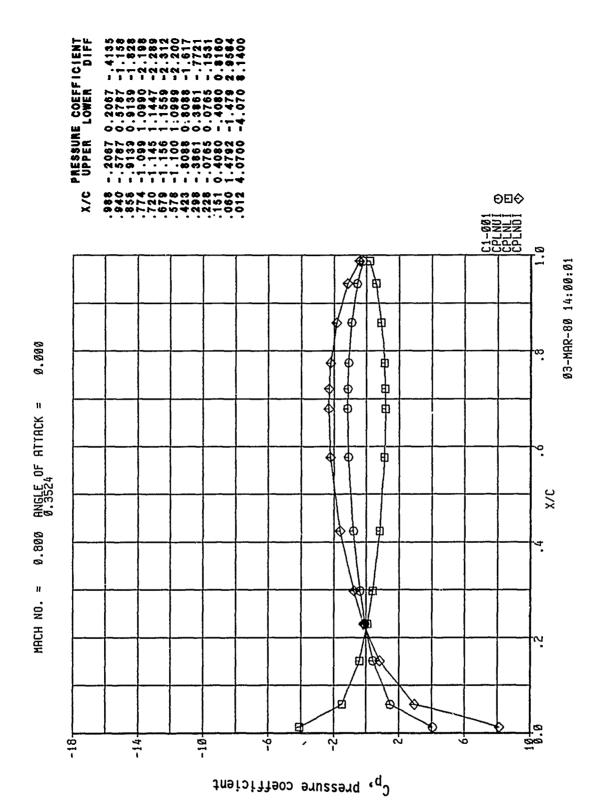


Figure 235, Chordwise Pressure Distribution, Imaginary, Configuration

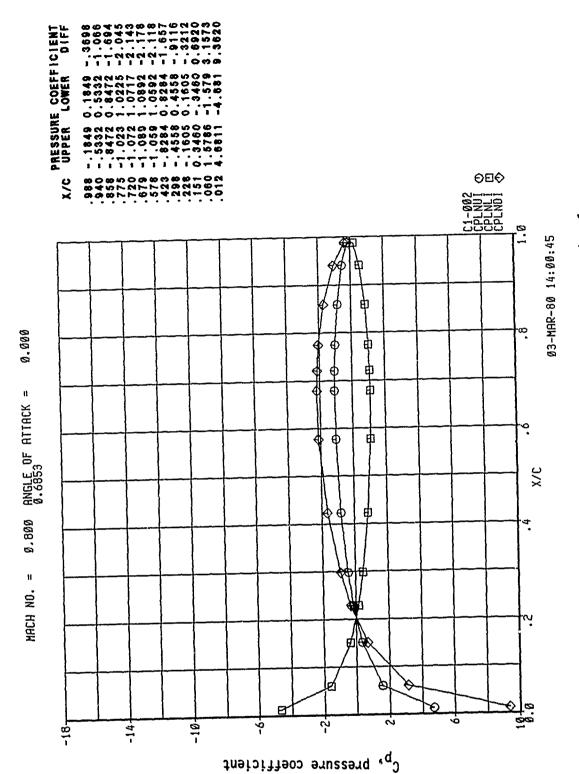


Figure 236, Chordwise Pressure Distribution, Imaginary, Configuration

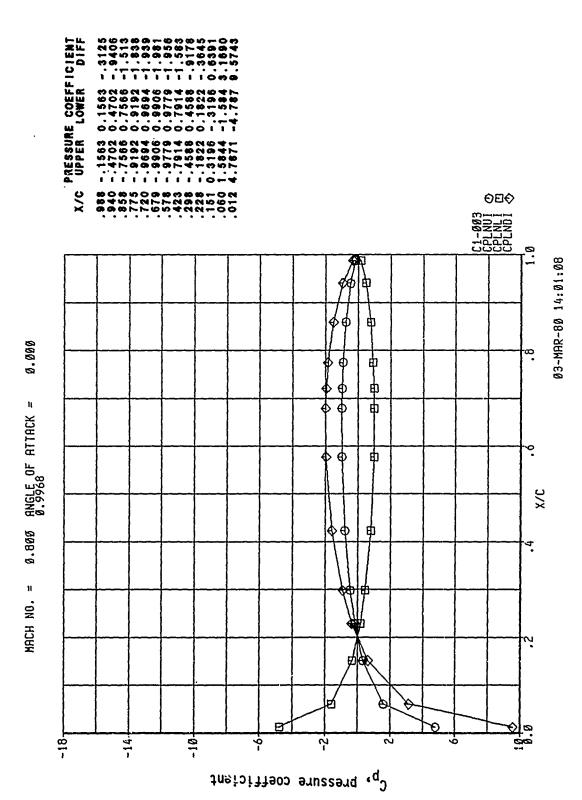


Figure 237, Chordwise Pressure Distribution, Imaginary, Configuration 1

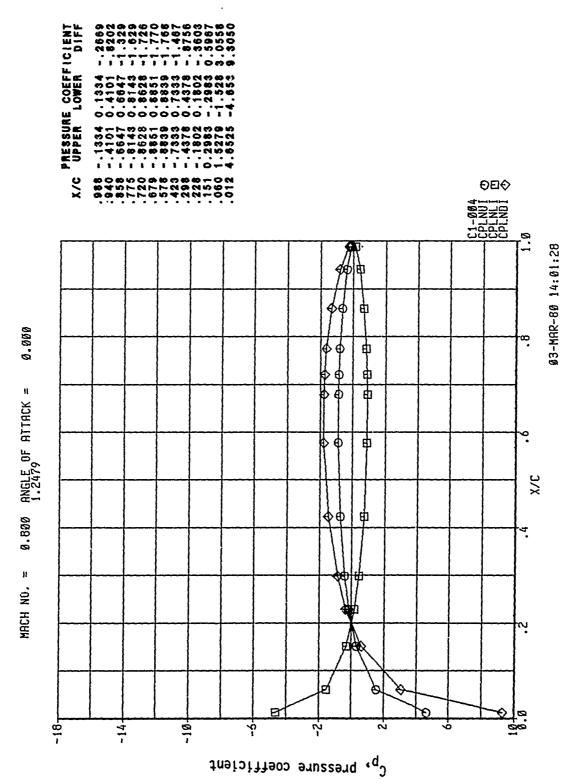
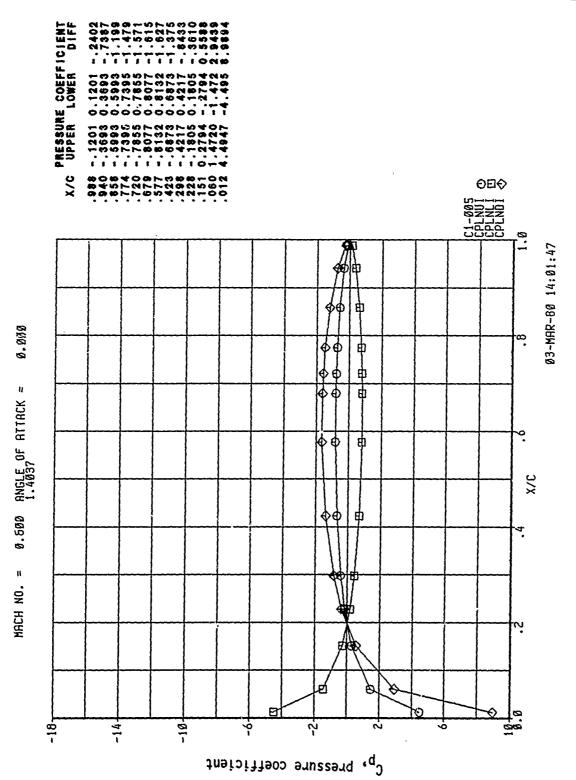


Figure 238, Chordwise Pressure Distribution, Imaginary, Configuration 1



239, Chordwise Pressure Distribution, Imaginary, Configuration Figure

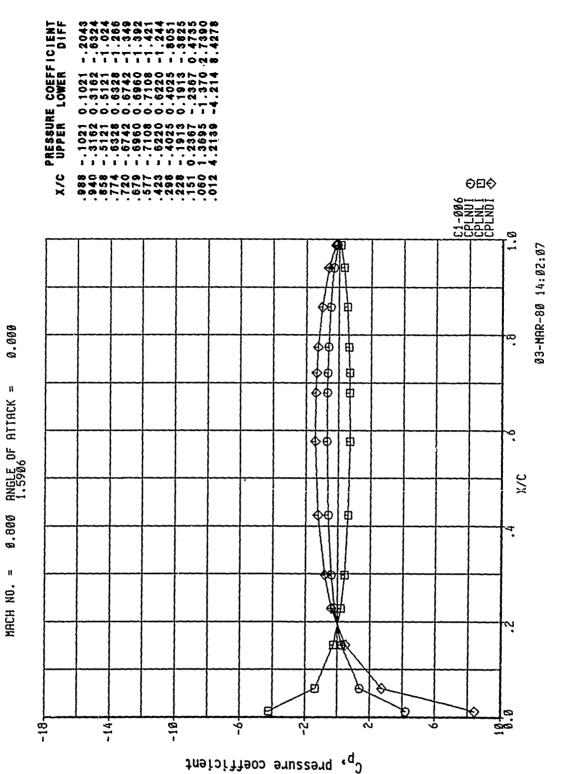


Figure 240, Chordwise Pressure Distribution, Imaginary, Configuration

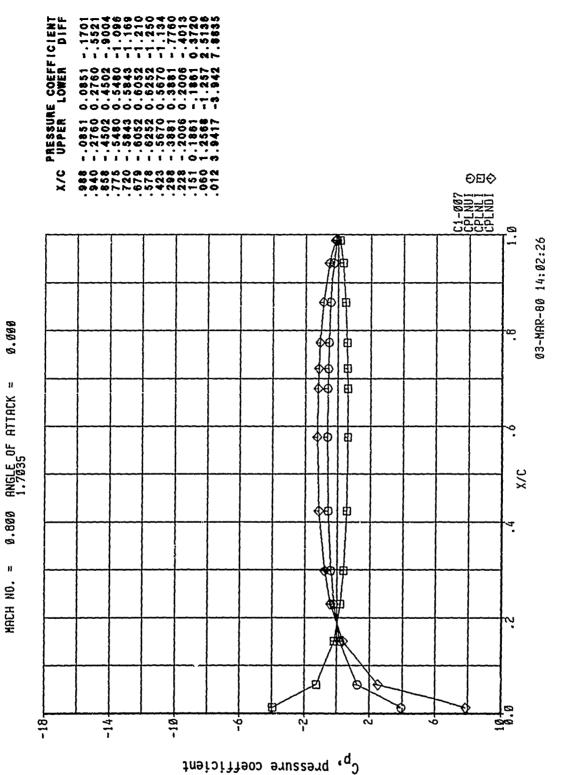
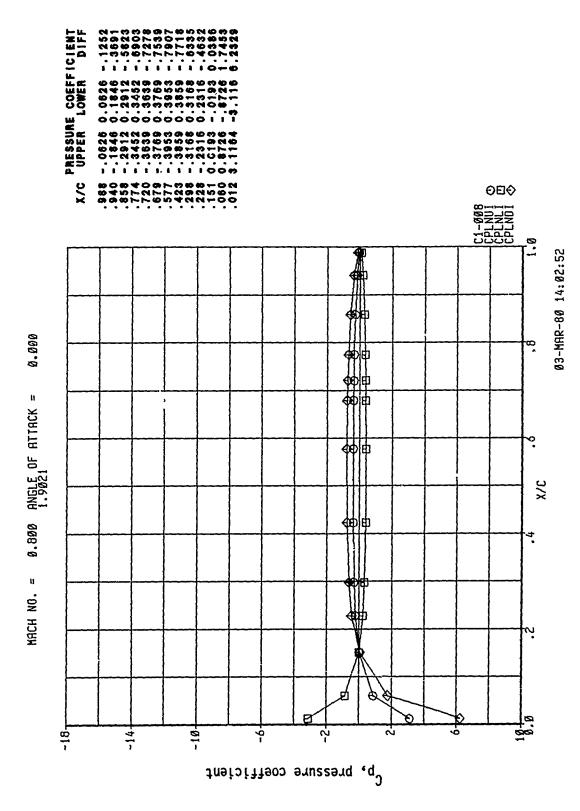


Figure 241, Chordwise Pressure Distribution, Imaginary, Configuration 1



275

Figure 243, Chordwise Pressure Distribution, Real, Configuration 1

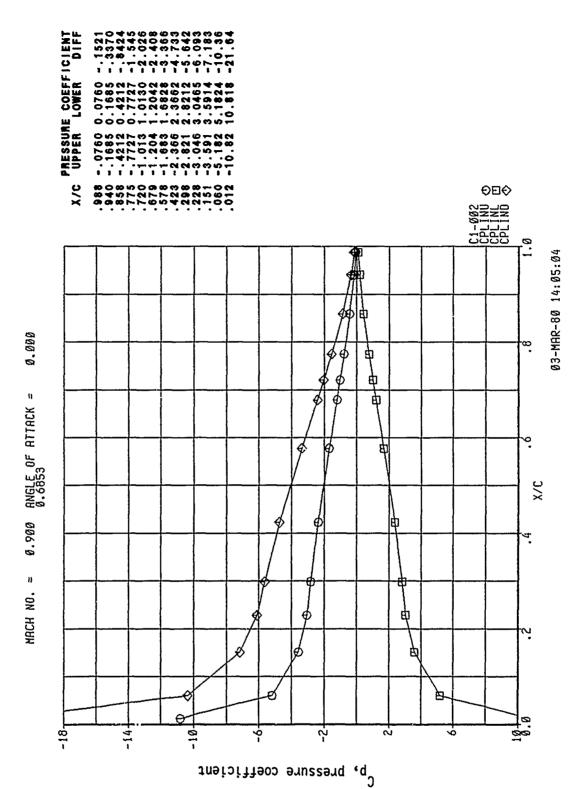
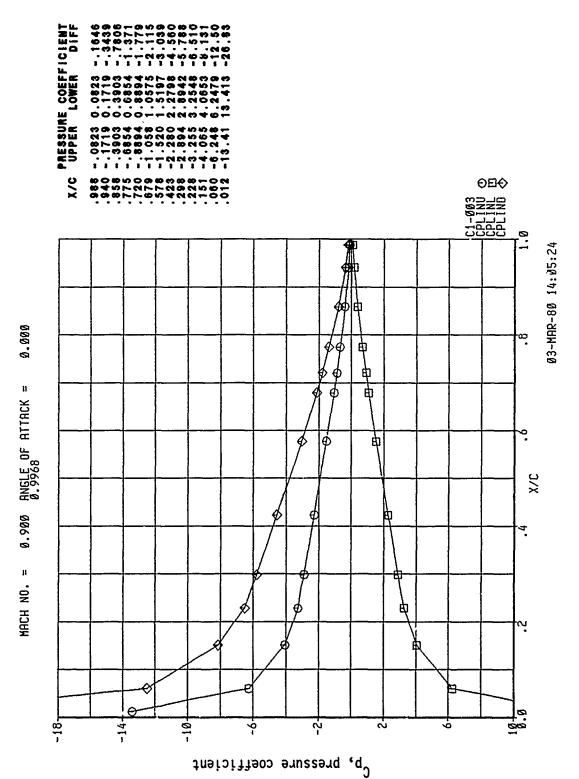


Figure 244, Chordwise Pressure Distribution, Real, Configuration 1



gure 245, Chordwise Pressure Distribution, Real, Configuration 1

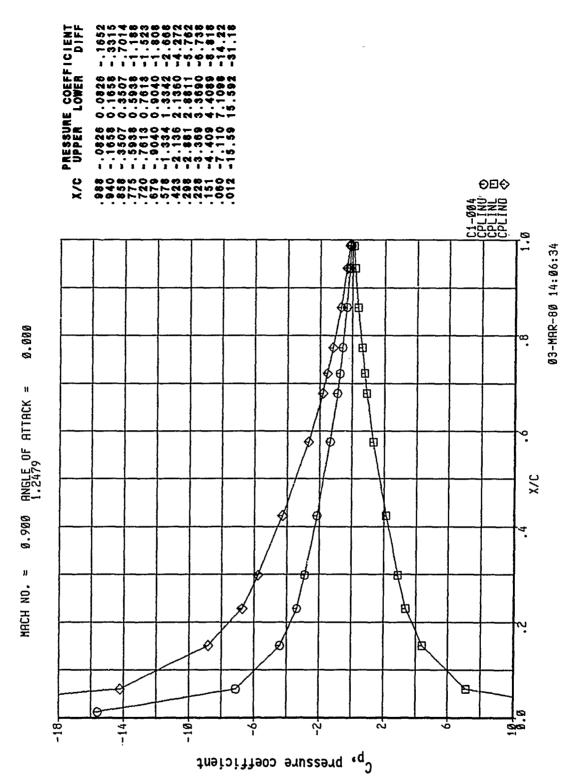


Figure 246, Chordwise Pressure Distribution, Real, Configuration 1

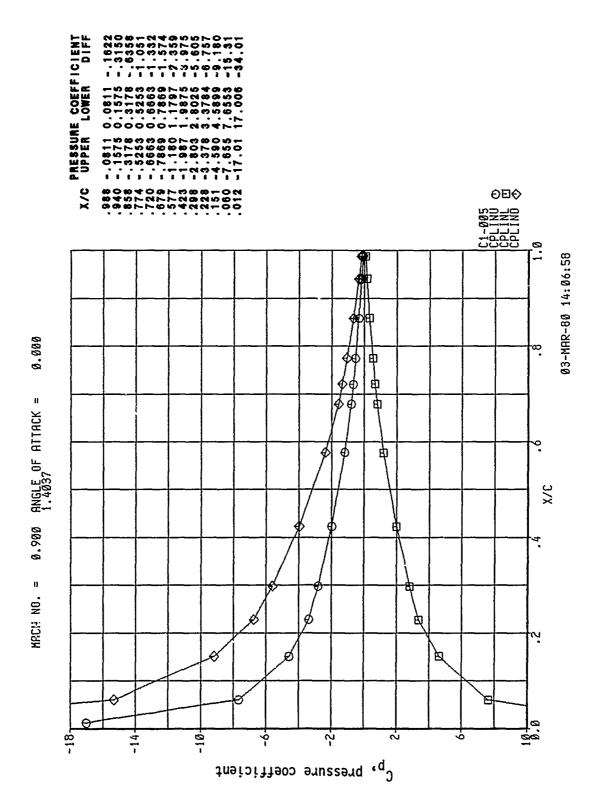


Figure 247, Chordwise Pressure Distribution, Real, Configuration 1

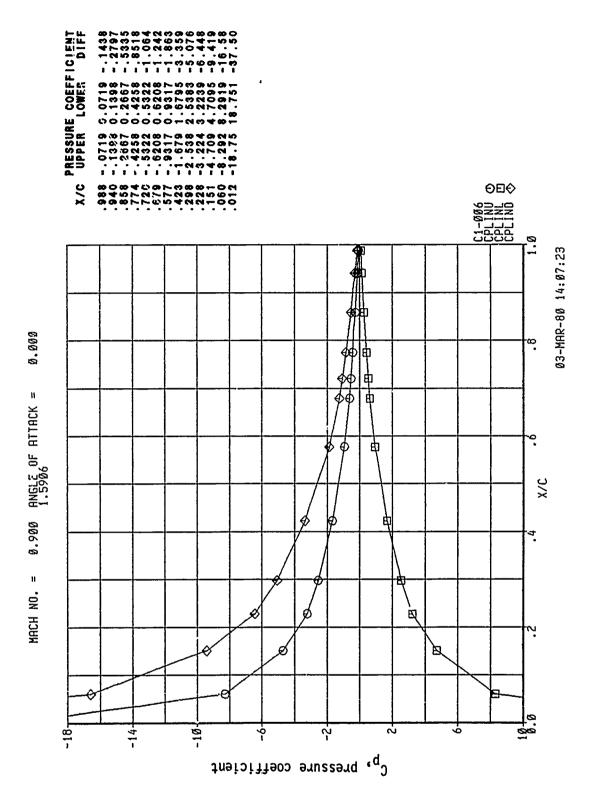


Figure 248, Chordwise Pressure Distribution, Real, Configuration 1

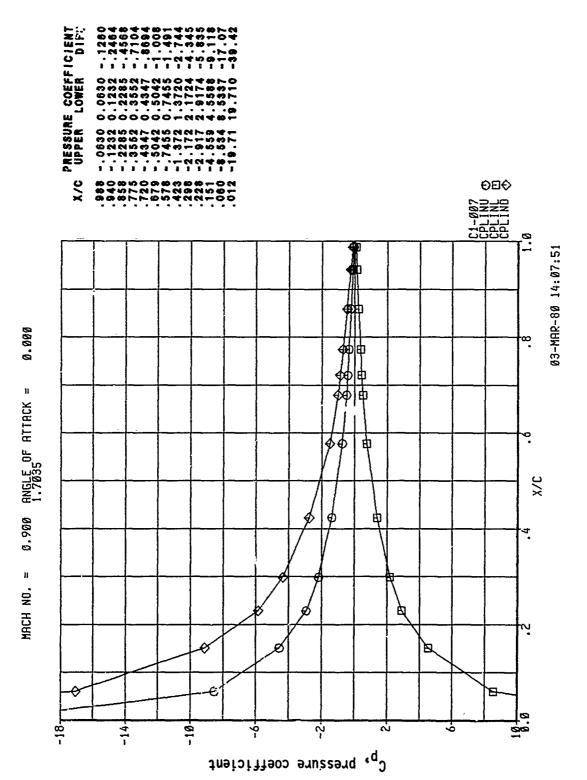


Figure 249, Chordwise Pressure Distribution, Real, Configuration 1

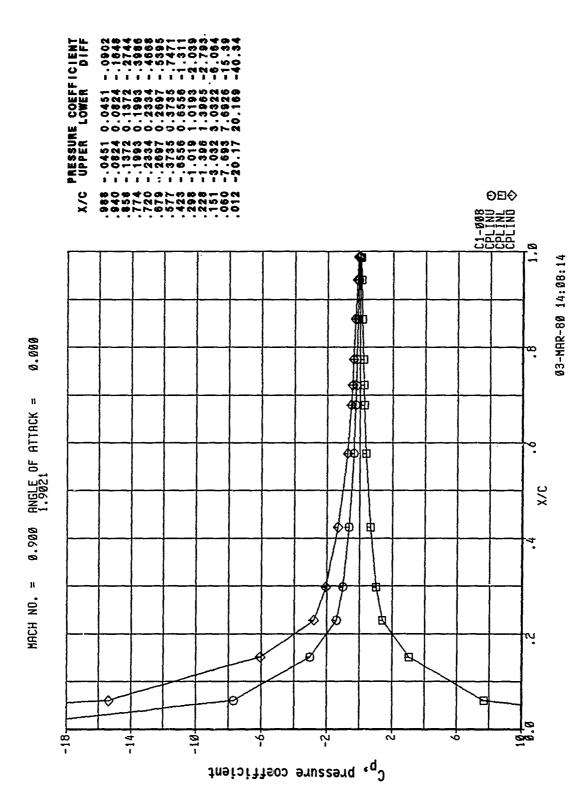
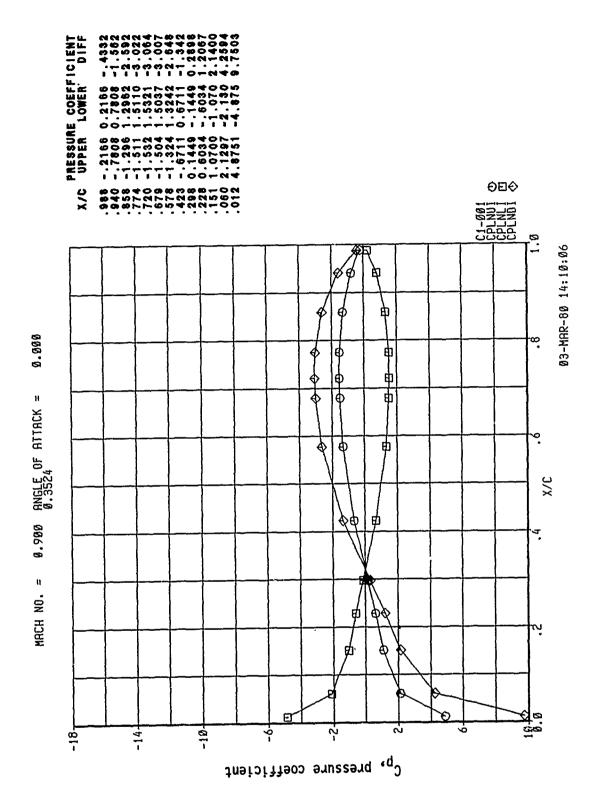


Figure 250, Chordwise Pressure Distribution, Real, Configuration 1



251, Chordwise Pressure Distribution, Imaginary, Configuration 1 Figure

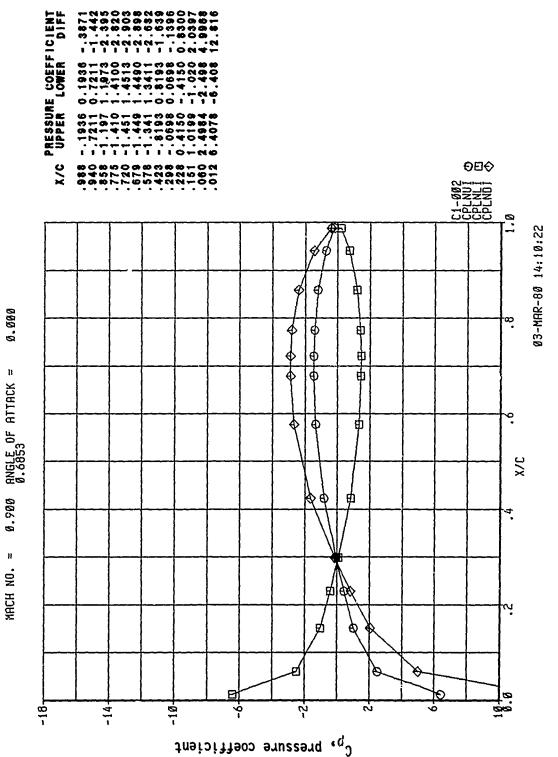


Figure 252, Chordwise Pressure Distribution, Imaginary, Configuration 1

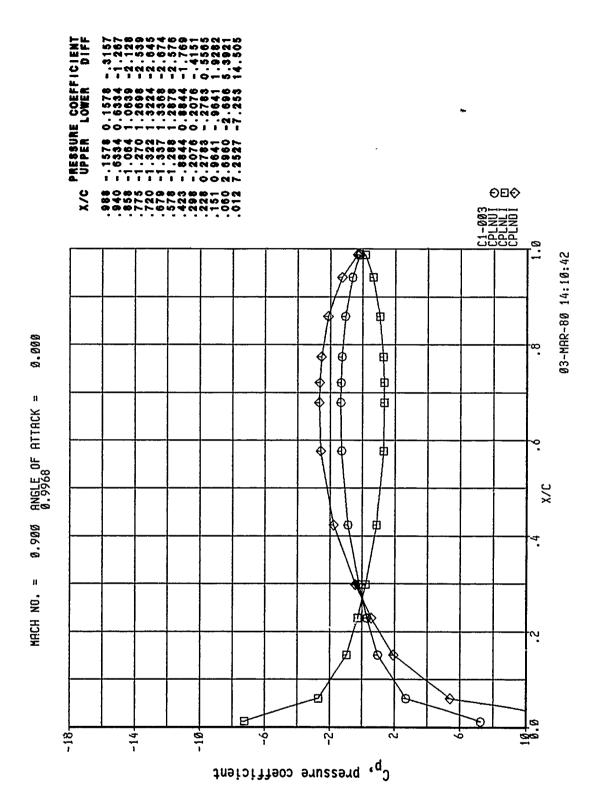


Figure 253, Chordwise Pressure Distribution, Imaginary, Configuration

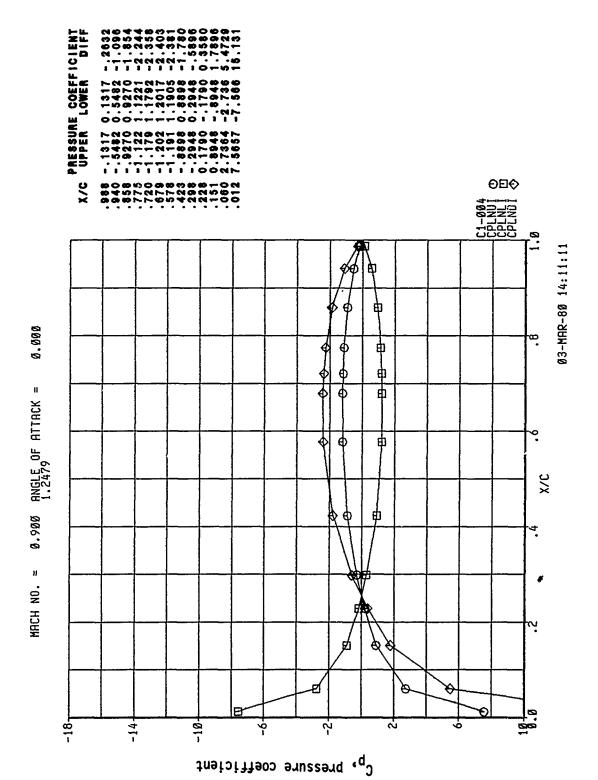


Figure 254, Chordwise Pressure Distribution, Imaginary, Configuration 1

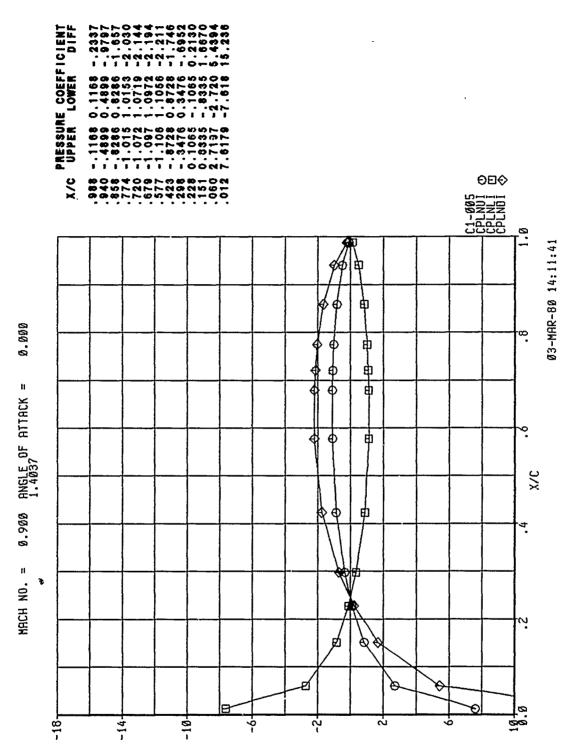


Figure 255, Chordwise Pressure Distribution, Imaginary, Configuration 1

 $C_{\mathbf{p}}$, pressure coefficient

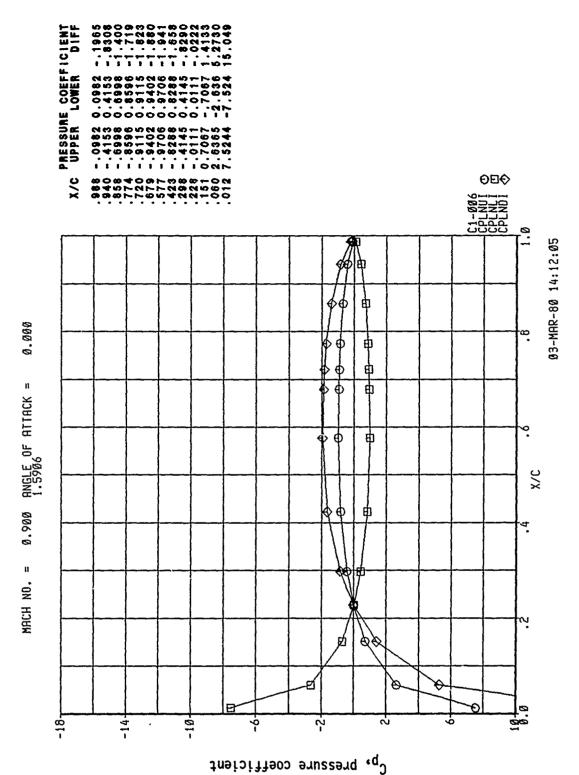
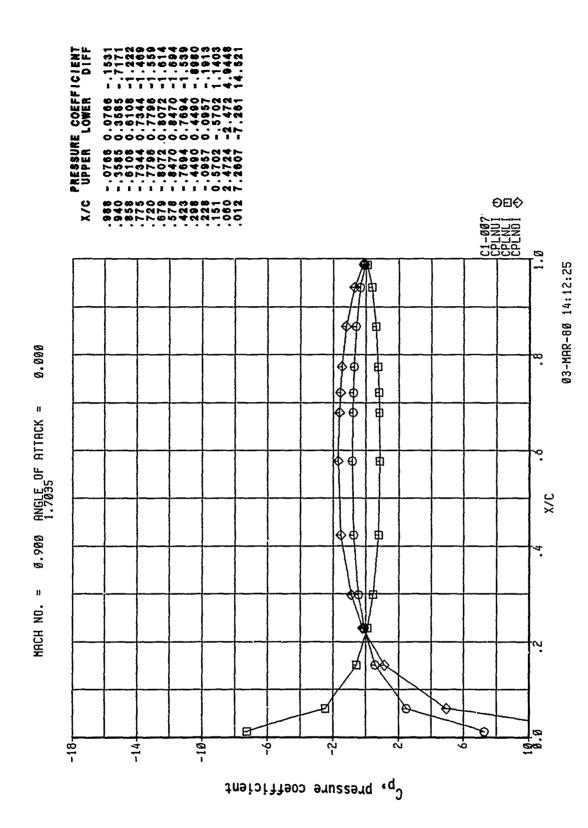


Figure 256, Chordwise Pressure Distribution, Imaginary, Configuration 1



 $^{'}$ Figure 257, Chordwise Pressure Distribution, Imaginary, Configuration 1

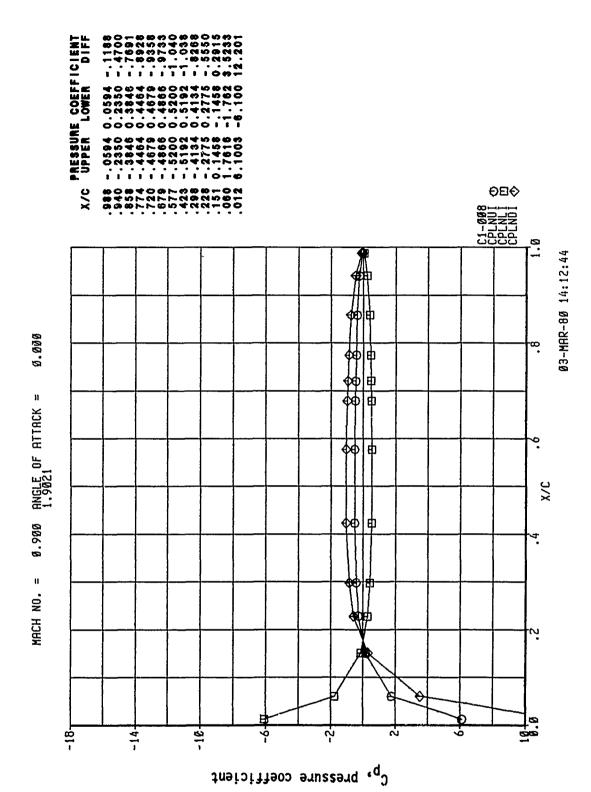


Figure 258, Chordwise Pressure Distribution, Imaginary, Configuration 1

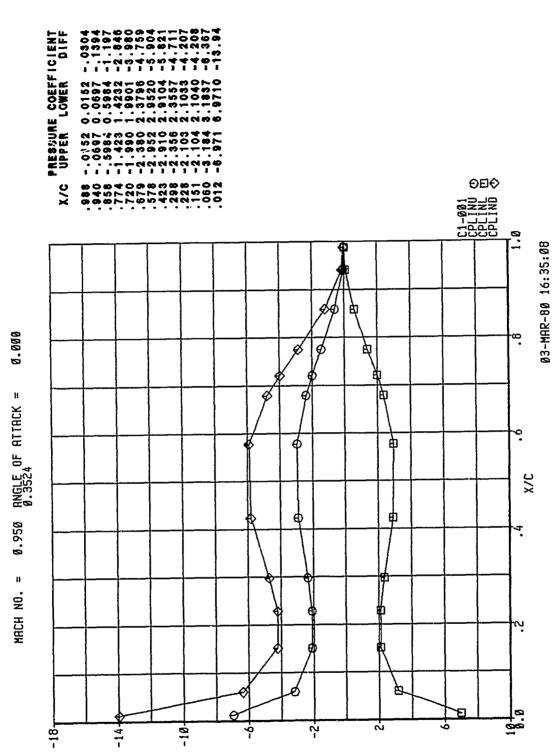


Figure 259, Chordwise Pressure Distribution, Real, Configuration 1

Cp. pressure coefficient

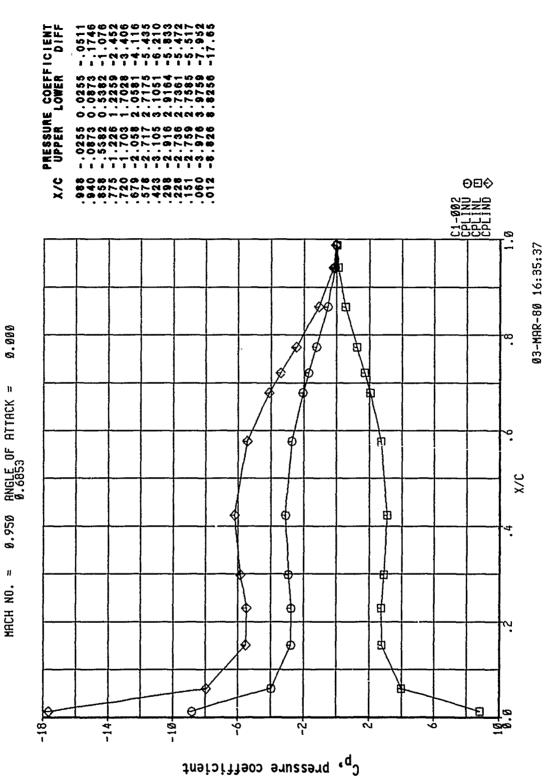


Figure 260, Chordwise Pressure Distribution, Real, Configuration 1

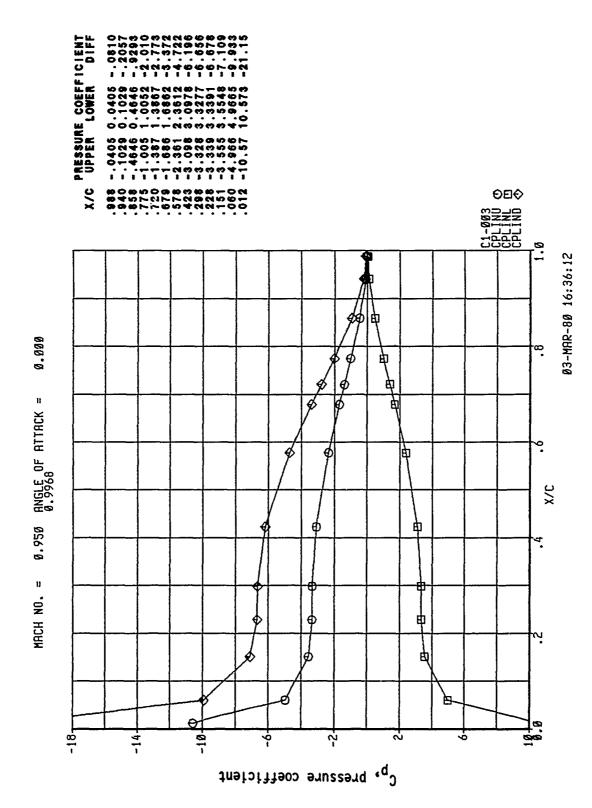


Figure 261, Chordwise Pressure Distribution, Real, Configuration 1

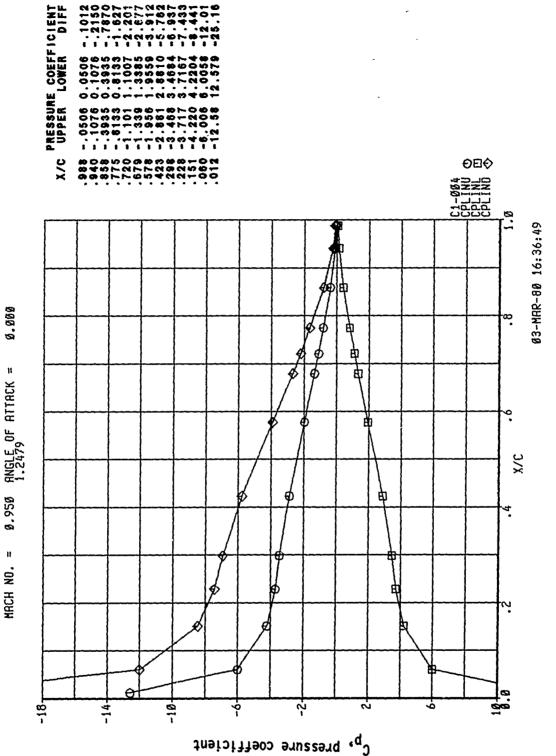


Figure 262, CMordwise Pressure Distribution, Real, Configuration 1

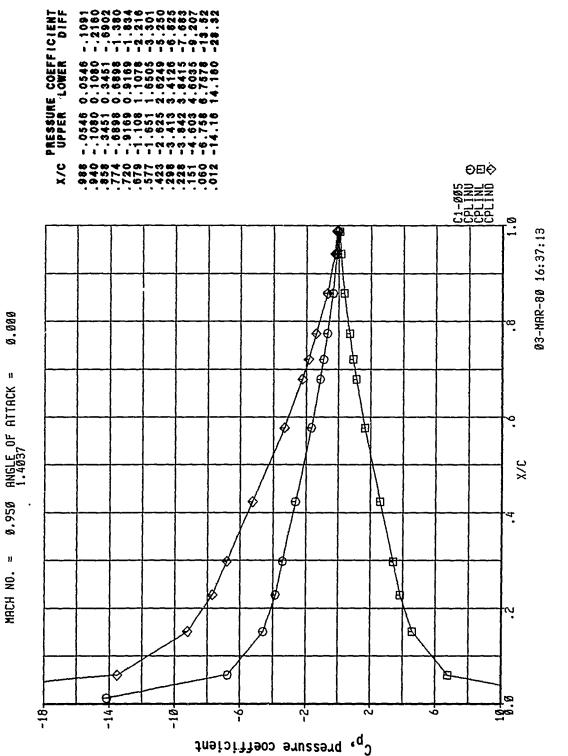


Figure 263, Chordwise Pressure Distribution, Real, Configuration 1

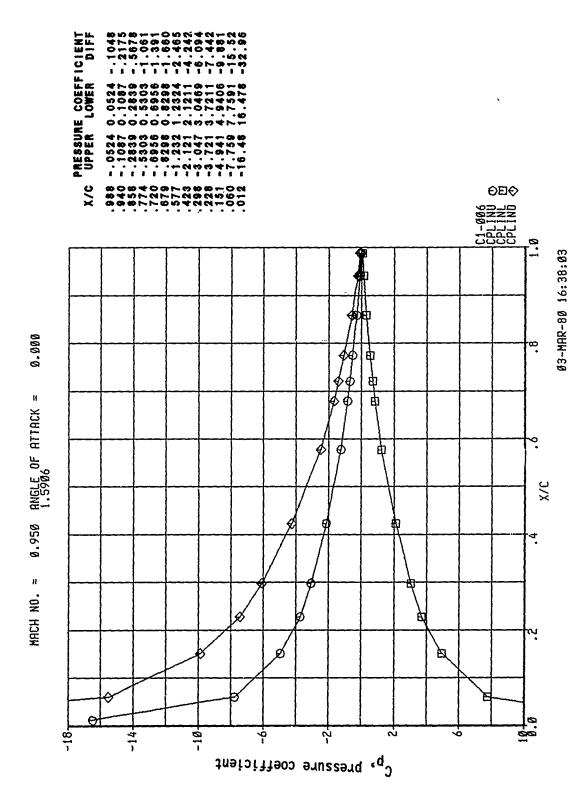
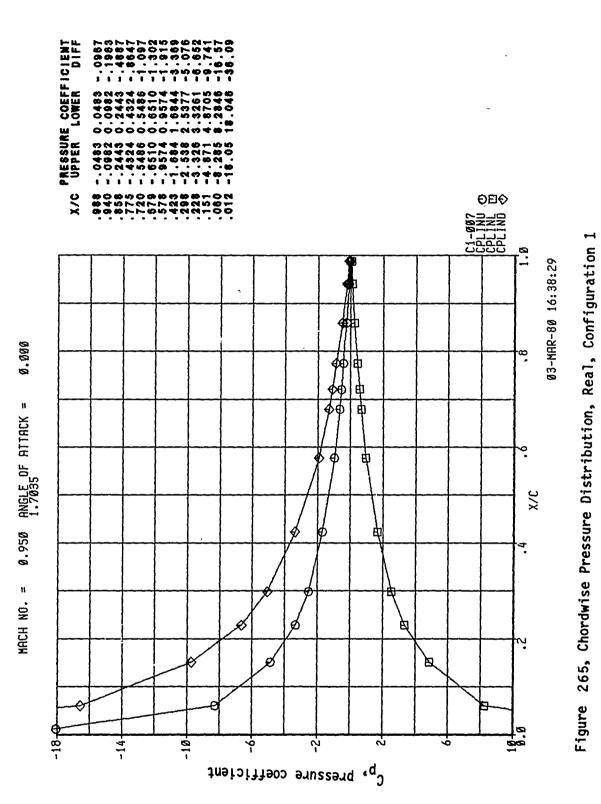


Figure 264, Chordwise Pressure Distribution, Real, Configuration 1



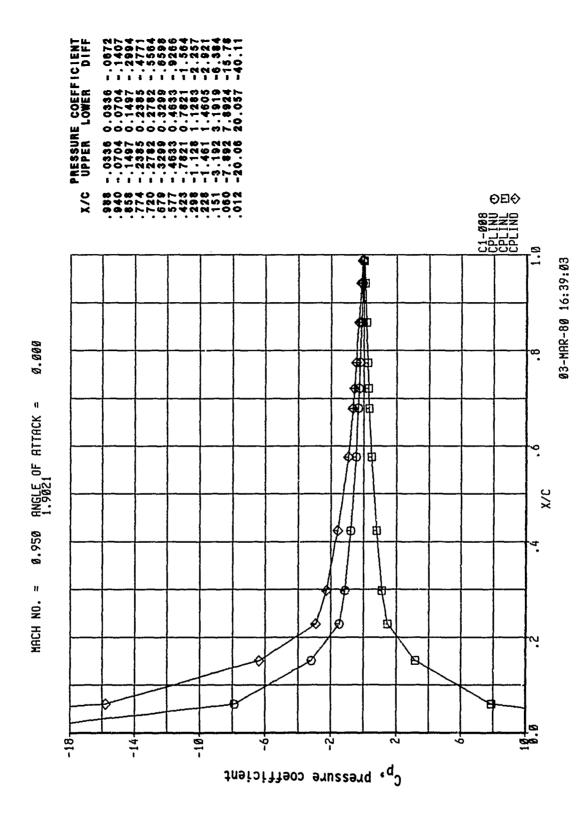


Figure 266, Chordwise Pressure Distribution, Real, Configuration 1

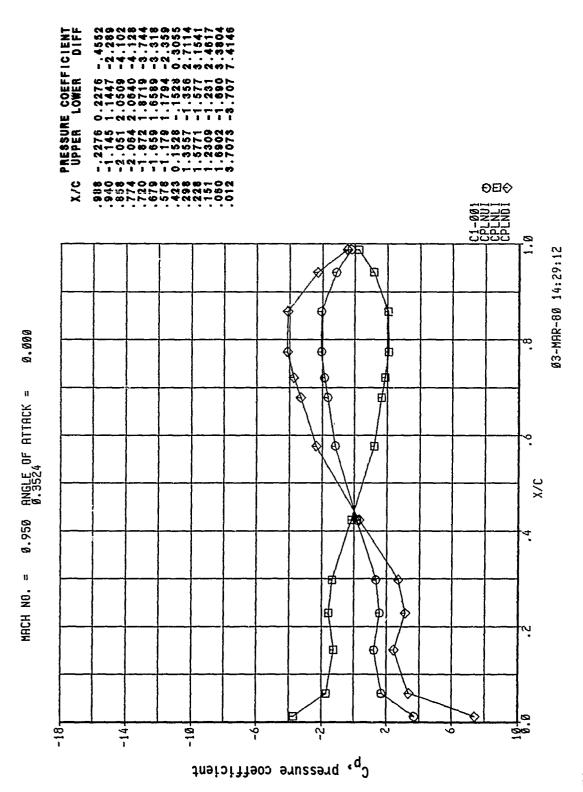


Figure 267, Chordwise Pressure Distribution, Imaginary, Configuration

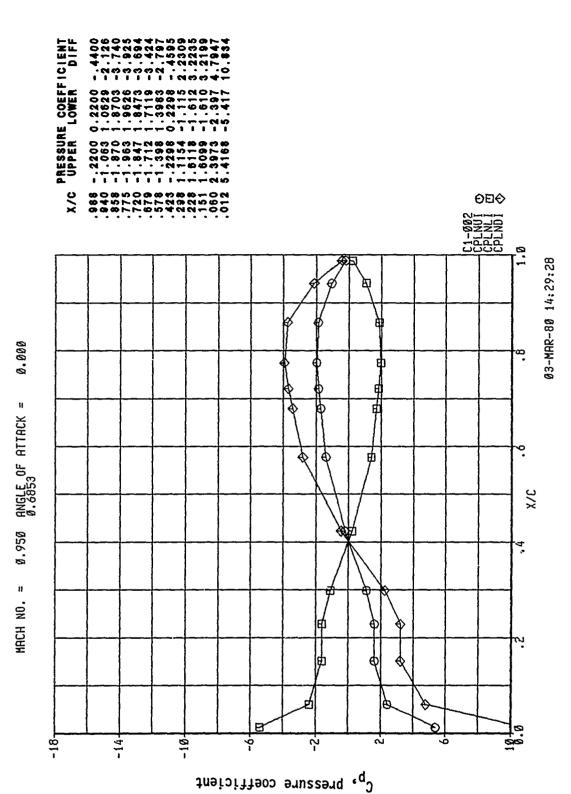


Figure 268, Chordwise Pressure Distribution, Imaginary, Configuration 1

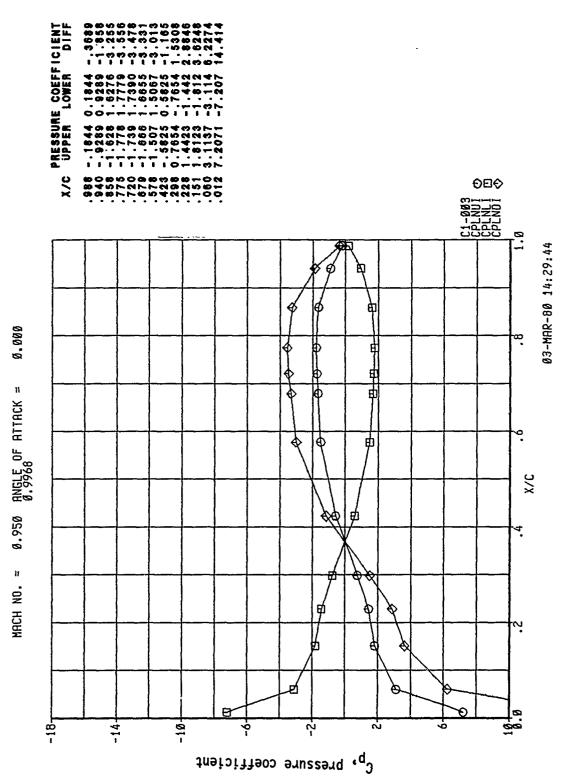


Figure 269, Chordwise Pressure Distribution, Imaginary, Configuration

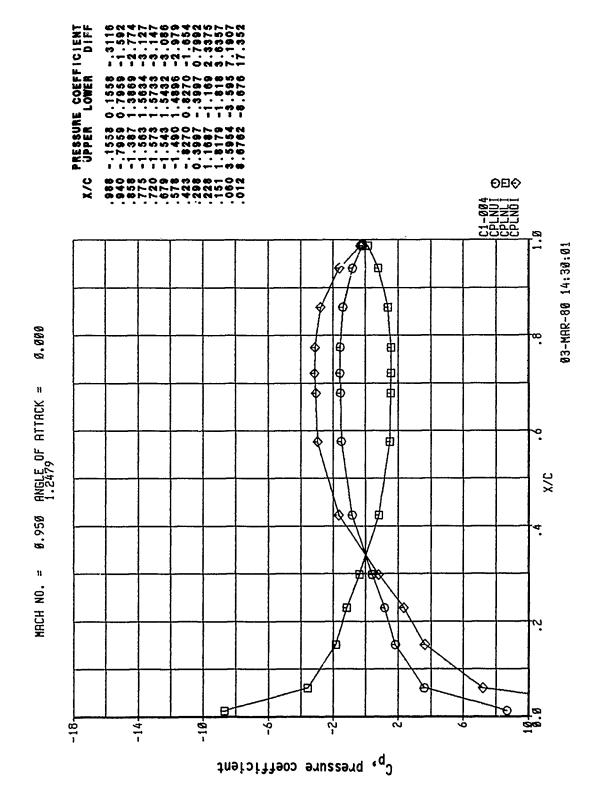


Figure 270, Chordwise Pressure Distribution, Imaginary, Configuration 1

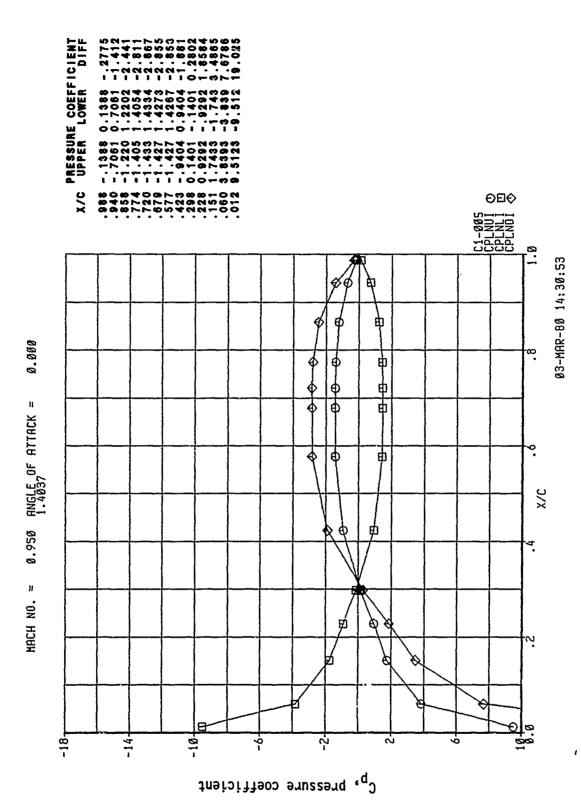


Figure 271, Chordwise Pressure Distribution, Imaginary, Configuration 1

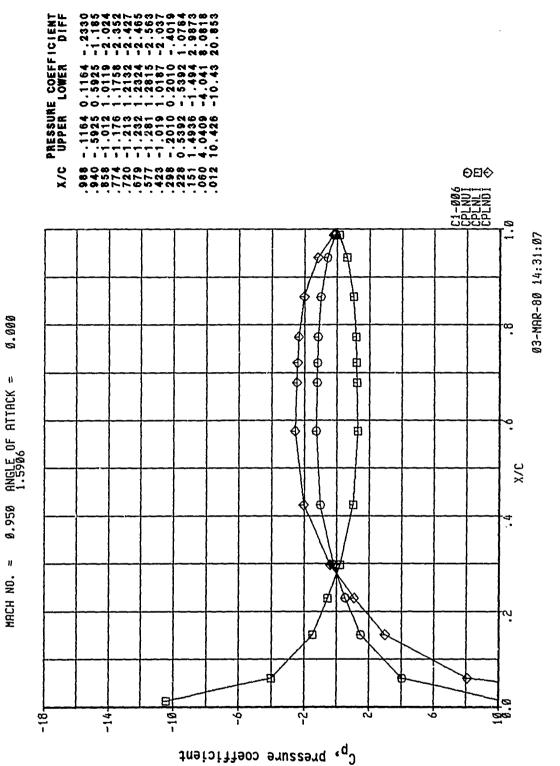


Figure 272, Chordwise Pressure Distribution, Imaginary, Configuration 1

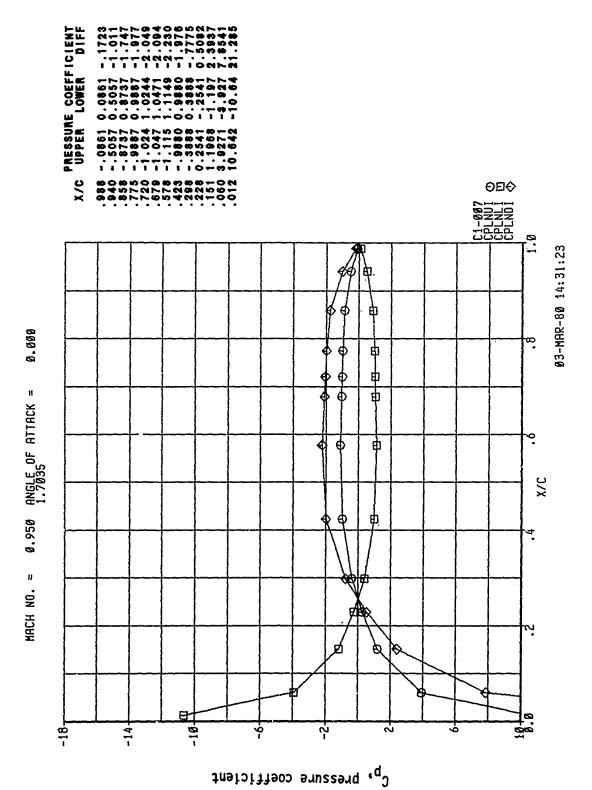


Figure 273, Chordwise Pressure Distribution, Imaginary, Configuration 1

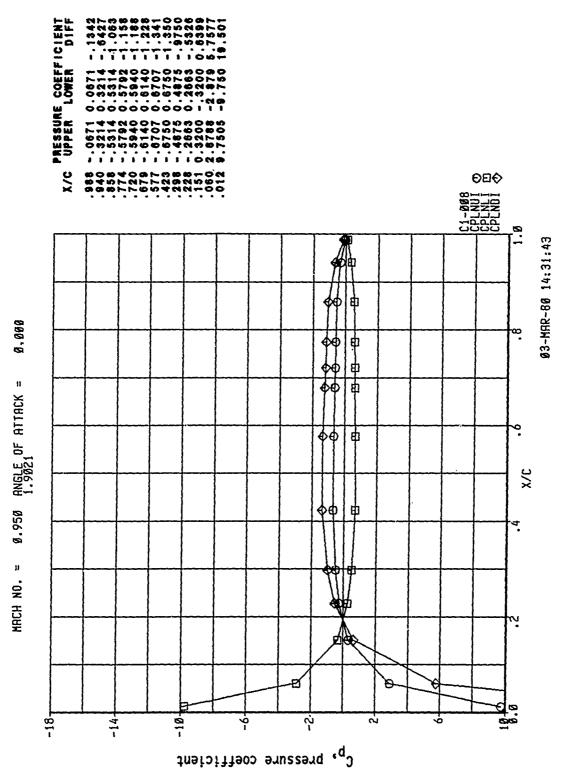
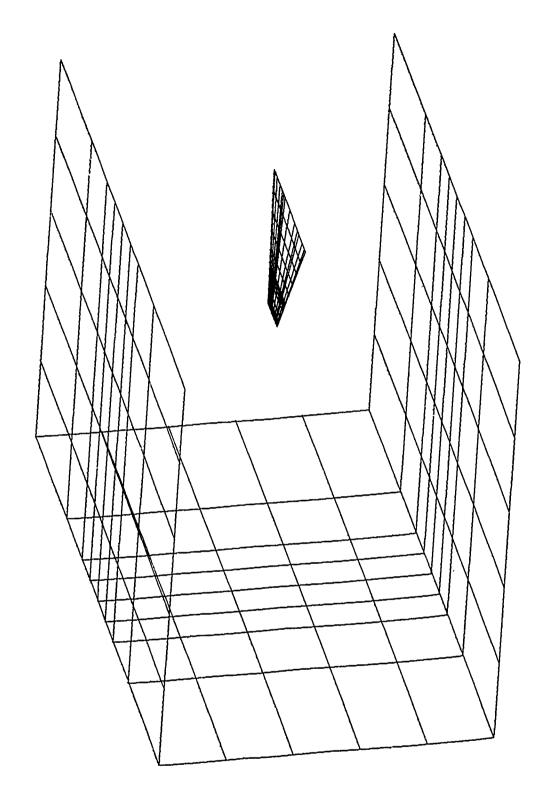


Figure 274, Chordwise Pressure Distribution, Imaginary, Configuration



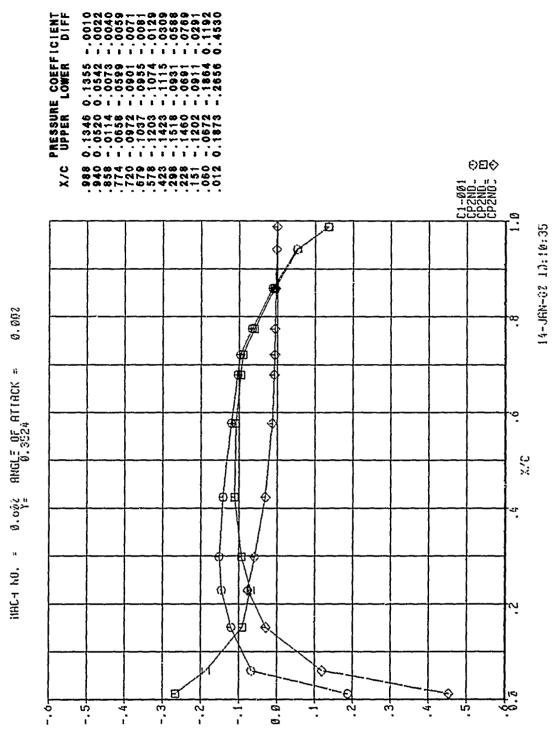


Figure 276, Chordwise Pressure Distribution, Steady, Configuration

theisiffees coefficient ${}^{\circ}_{q}$

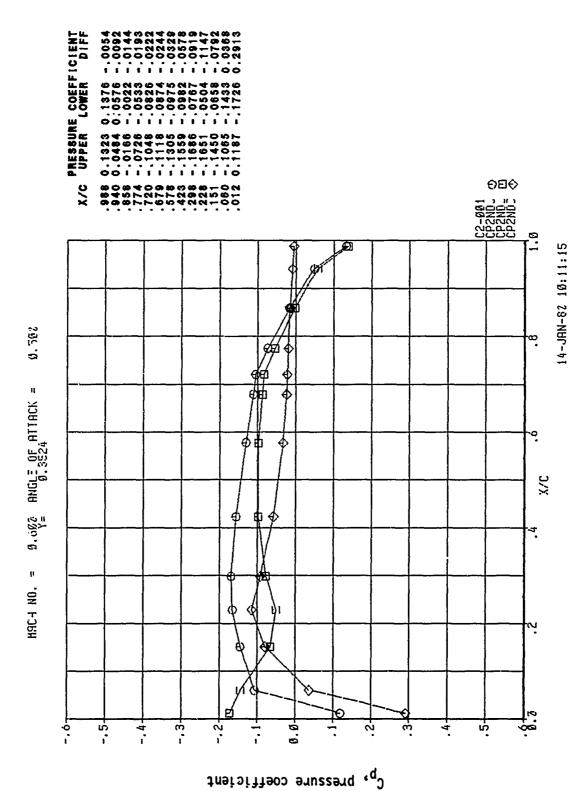


Figure 277, Chordwise Pressure Distribution, Steady, Configuration

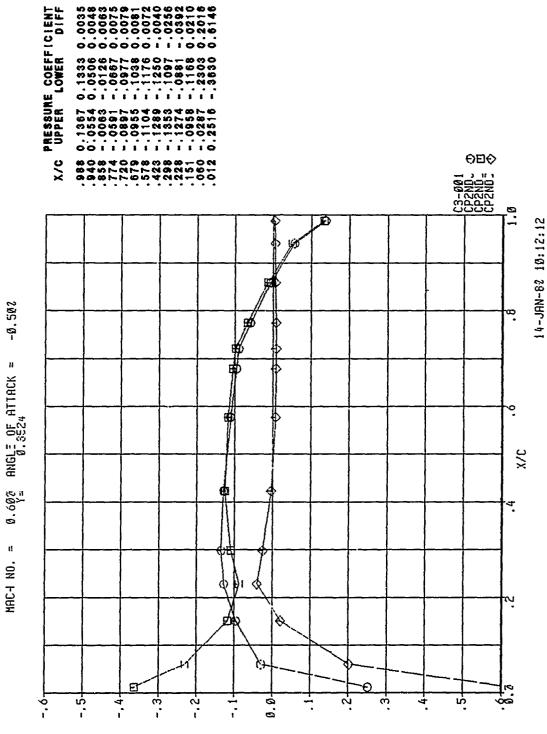


Figure 278, Chordwise Pressure Distribution, Steady, Configuration

 $c_{
m p}$, pressure coefficient

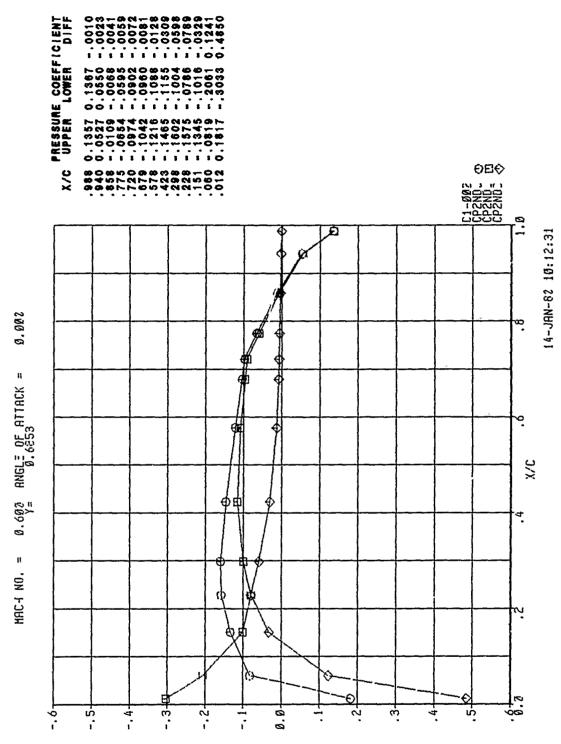
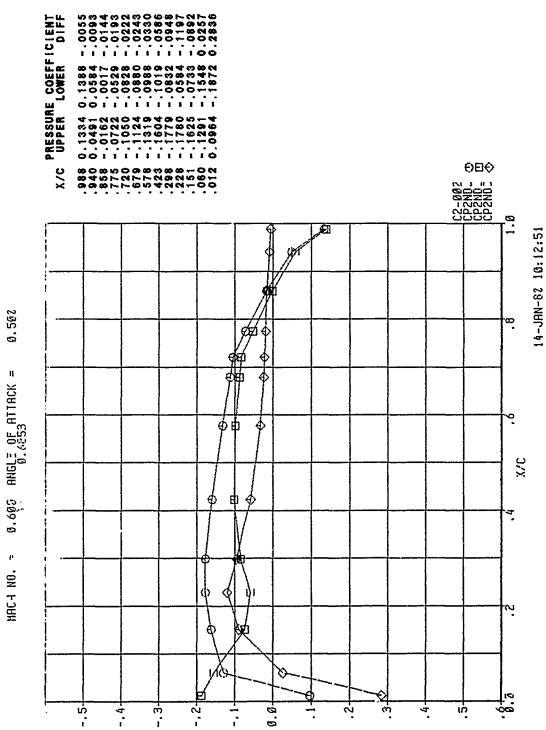


Figure 279, Chordwise Pressure Distribution, Steady, Configuration 2

C_p, pressure coefficient



ς,

Figure 280, Chordwise Pressure Distribution, Steady, Configuration

tressure coefficient $_{
m q}$

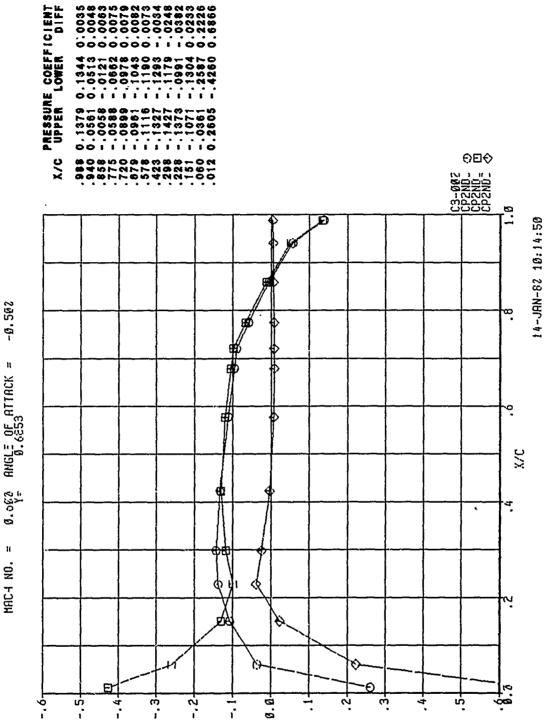


Figure 281, Chordwise Pressure Distribution, Steady, Configuration

fressure coefficient

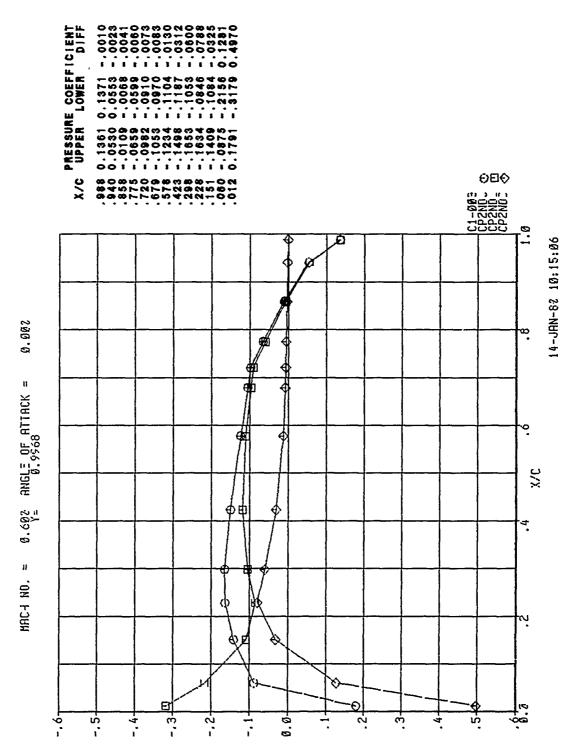


Figure 282, Chordwise Pressure Distribution, Steady, Configuration

C_p, pressure coefficient

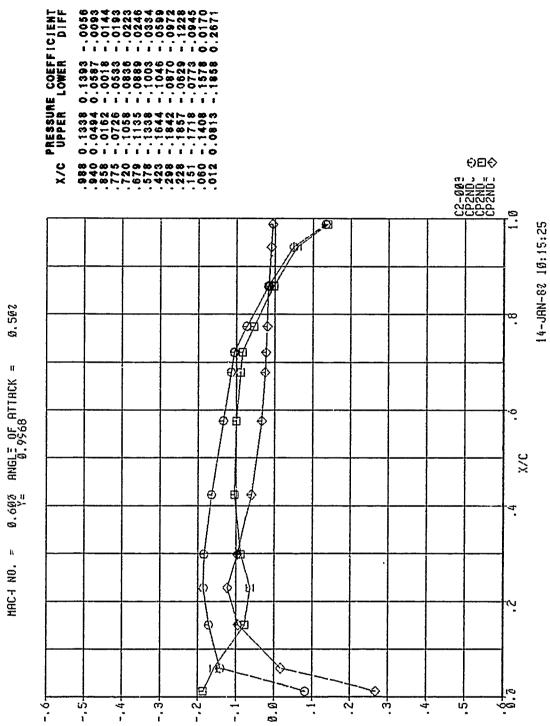
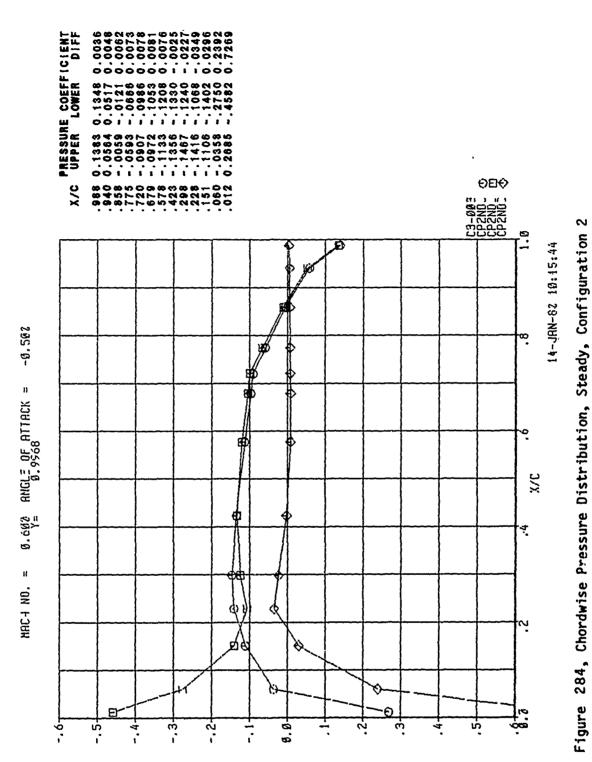


Figure 283, Chordwise Pressure Distribution, Steady, Configuration 2

ქომiეiTT900 მუwszerd 'qე



 C_{p} , pressure coefficient

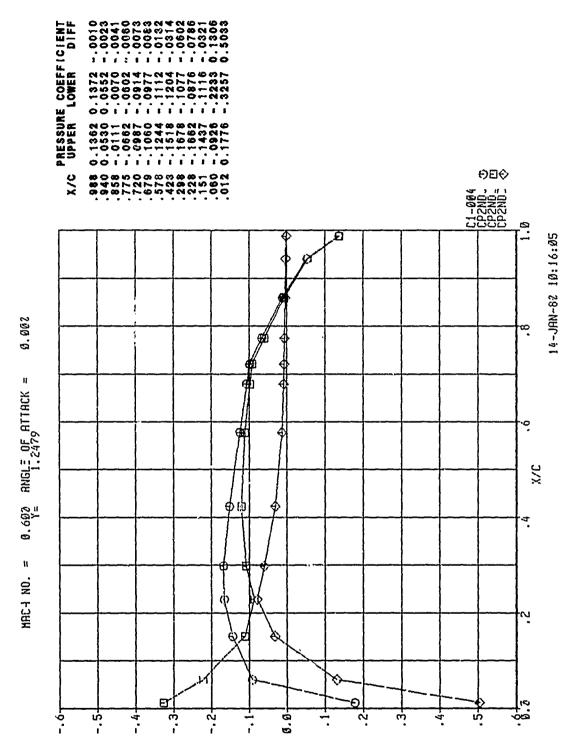


Figure 285, Chordwise Pressure Distribution, Steady, Configuration

 $\mathbf{C}_{\mathbf{p}}$, pressure coefficient

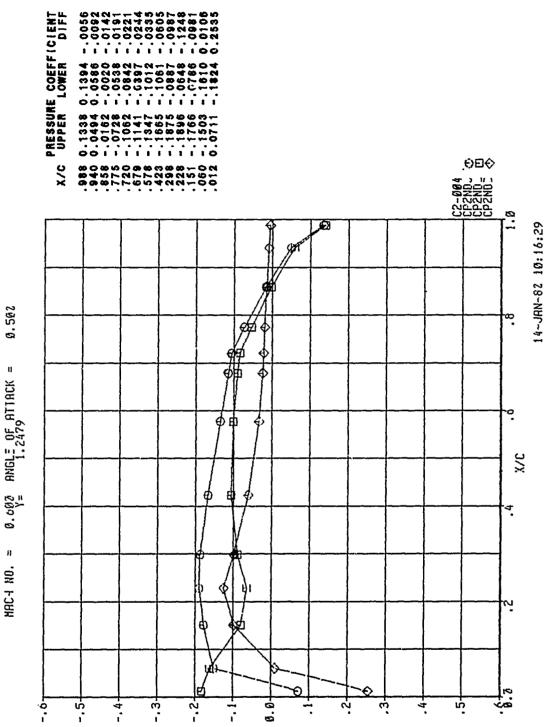
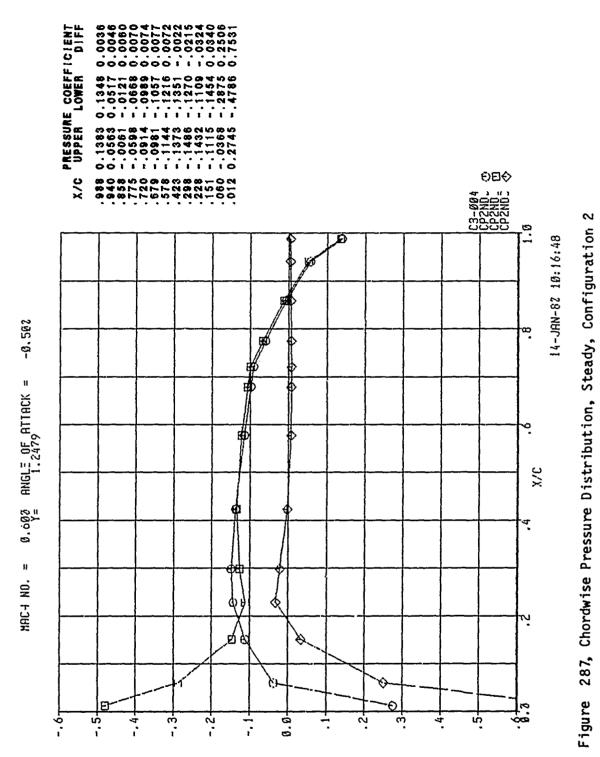


Figure 286, Chordwise Pressure Distribution, Steady, Configuration 2

theisiffeos successfy $\mathfrak{q}^{\mathsf{D}}$



 $C_{\mathbf{p}}$, pressure coefficient

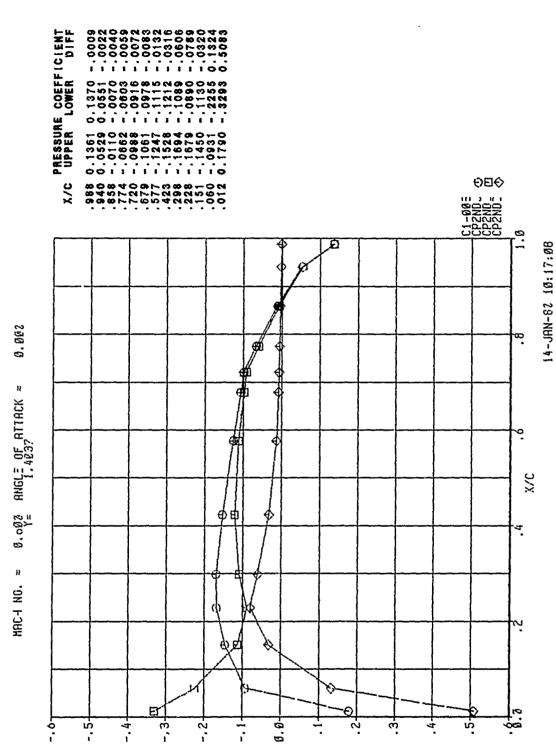


Figure 288, Chordwise Pressure Distribution, Steady, Configuration

C_p, pressure coefficient

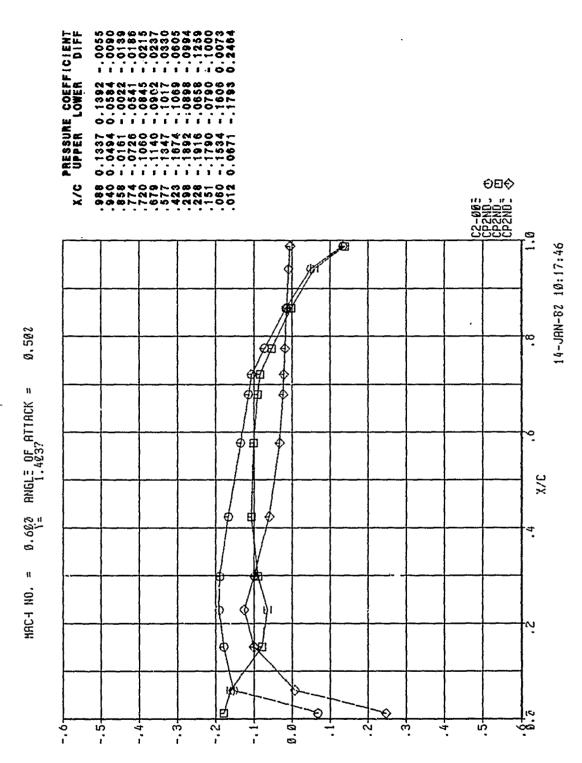


Figure 289, Chordwise Pressure Distribution, Steady, Configuration 2

theisittees coefficient $\mathfrak{q}_{\mathbf{p}}$

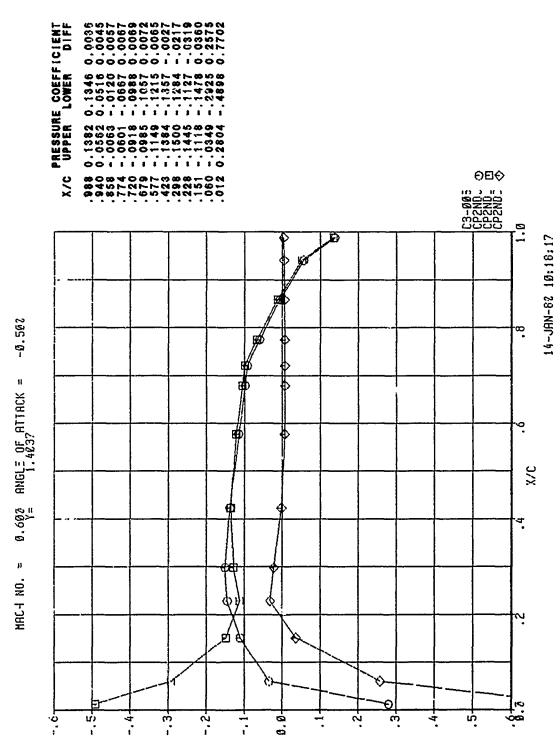


Figure 290, Chordwise Pressure Distribution, Steady, Configuration

C_p, pressure coefficient

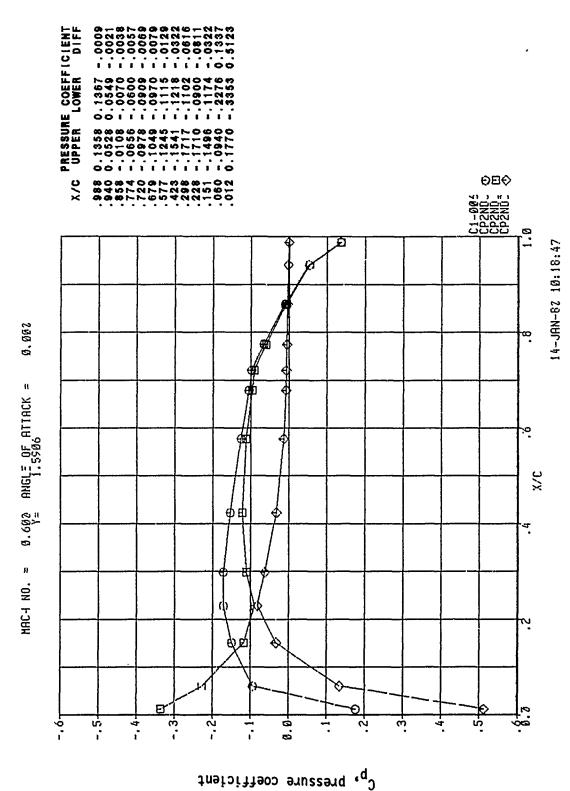


Figure 291, Chordwise Pressure Distribution, Steady, Configuration

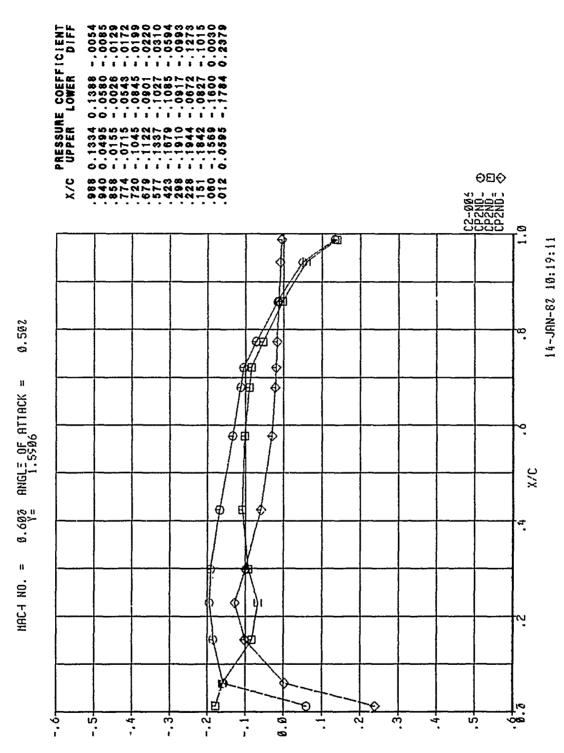
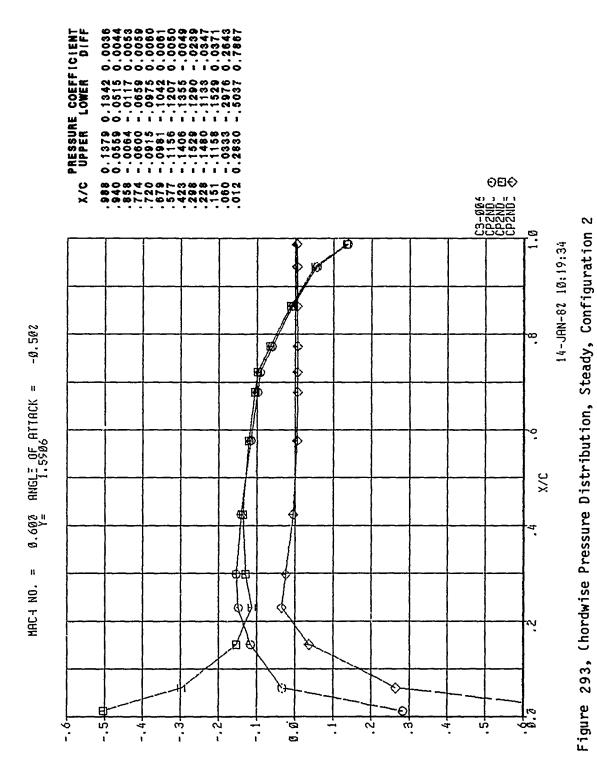
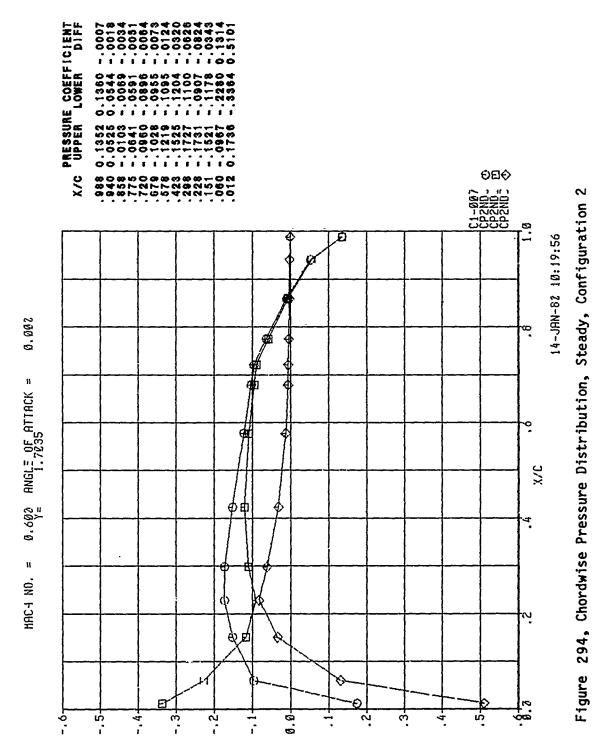


Figure 292, Chordwise Pressure Distribution, Steady, Configuration

 $\textbf{C}_{\textbf{p}},$ pressure coefficient



 $C_{\mathbf{p}}$, pressure coefficient



 $C_{\mathbf{p}}$, pressure coefficient

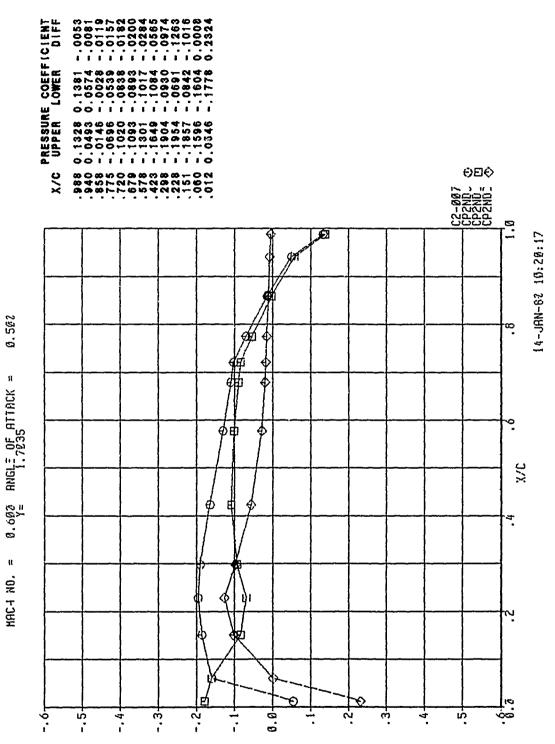


Figure 295, Chordwise Pressure Distribution, Steady, Configuration

Institition shows \mathbf{coeff} is \mathbf{coeff}

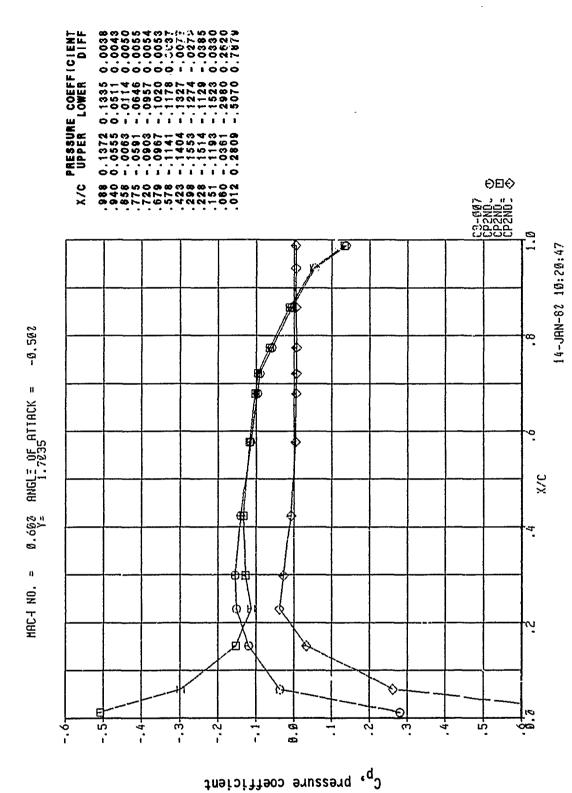
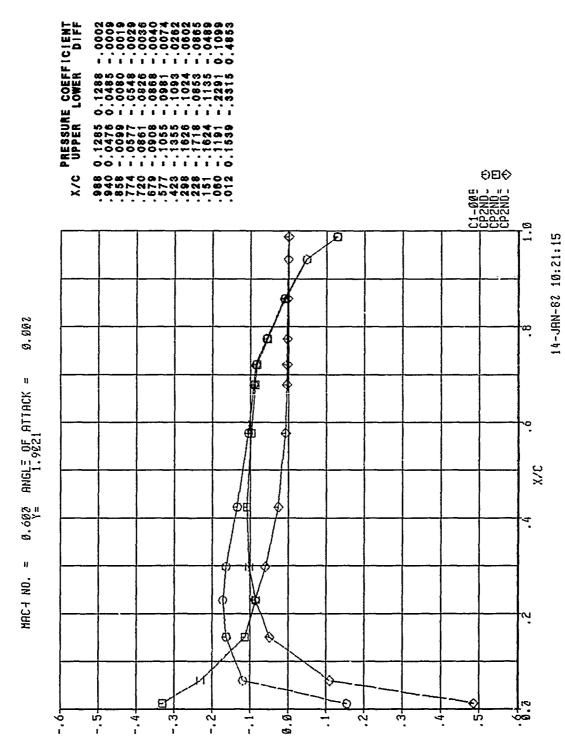
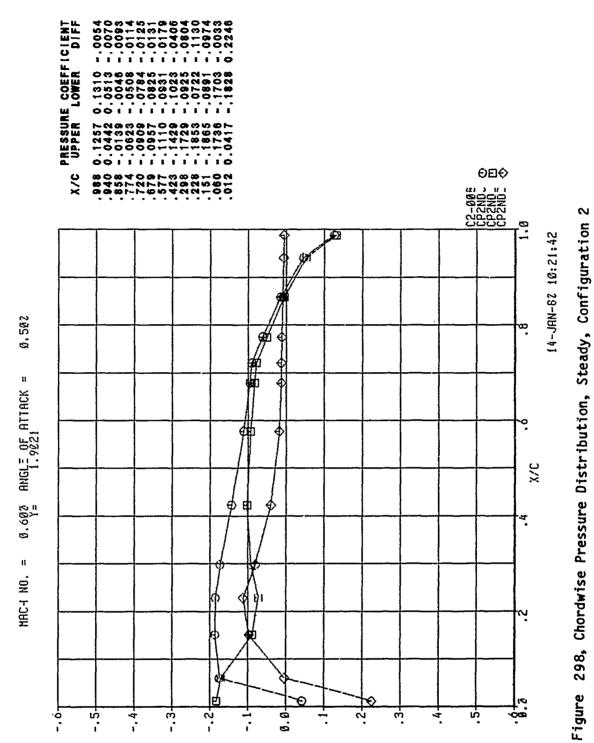


Figure 296, Chordwise Pressure Distribution, Steady, Configuration



297, Chordwise Pressure Distribution, Steady, Configuration

 $\sigma_{\rm p}$, pressure coefficient



theisiffeos enusserd ${}^{\prime}q$

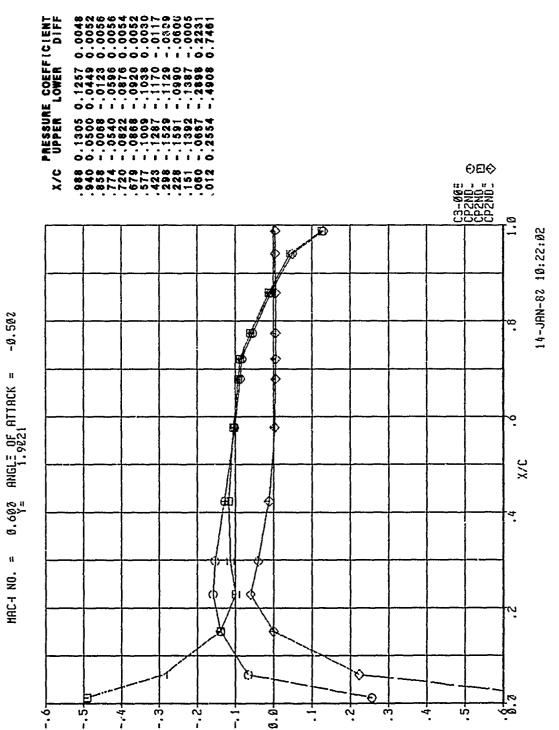


Figure 299, Chordwise Pressure Distribution, Steady, Configuration 2

C_p, pressure coefficient

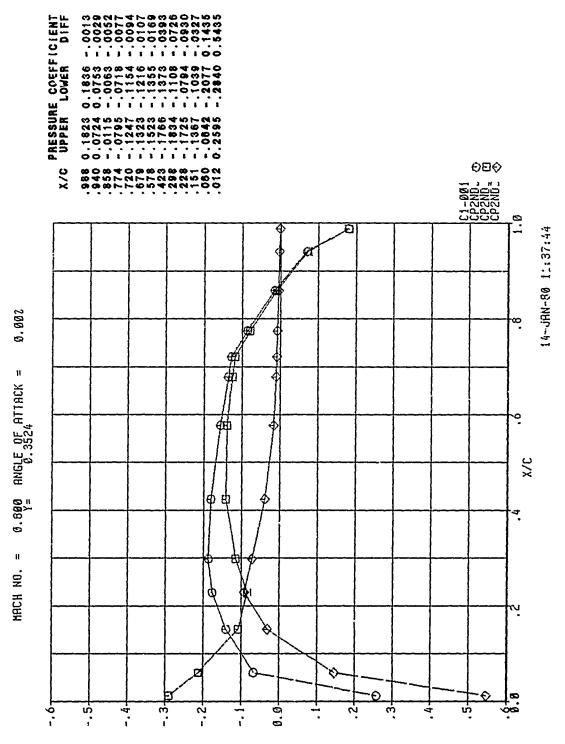
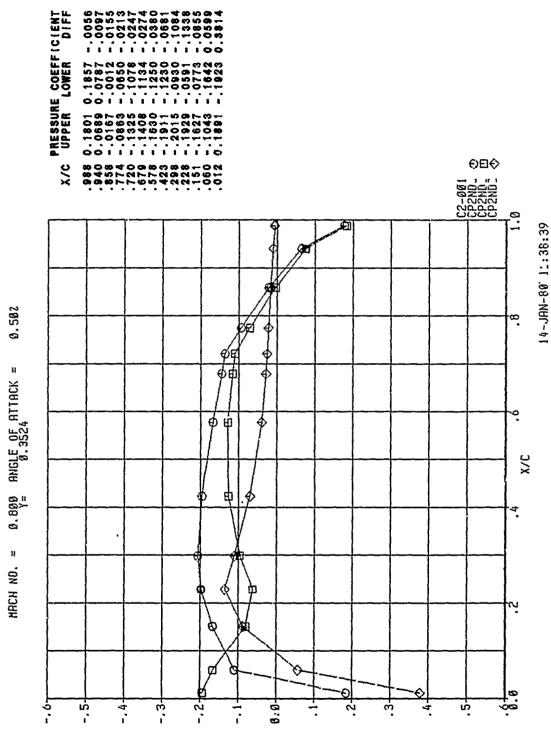


Figure 300, Chordwise Pressure Distribution, Steady, Configuration

 C_{p} , pressure coefficient



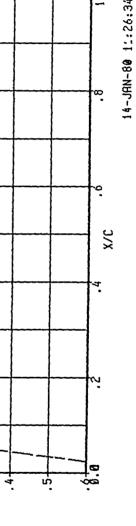
301, Chordwise Pressure Distribution, Steady, Configuration

Figure

Jpressure coefficient

MACH NO.

-, 5



⊕⊟**⊕**

 \sim

Figure 302, Chordwise Pressure Distribution, Steady, Configuration

C_p, pressure coefficient

19.0-

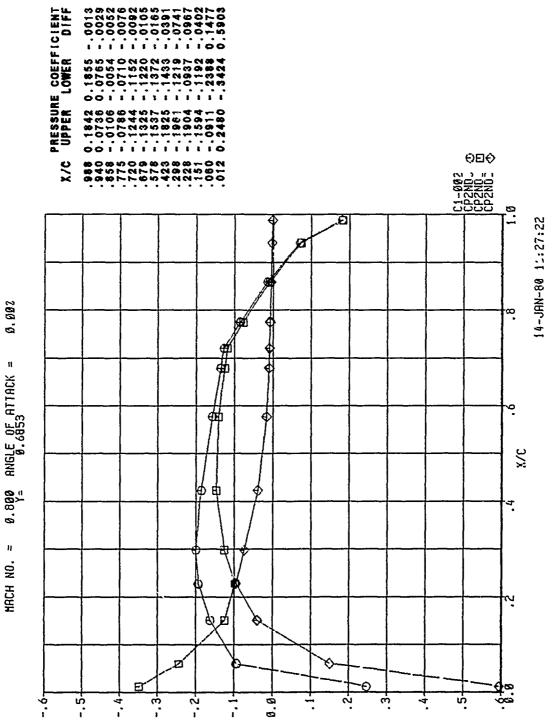
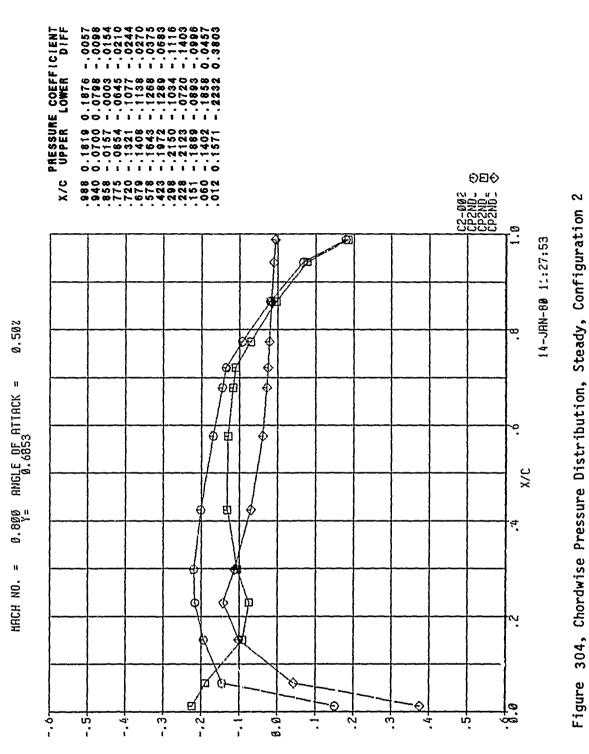


Figure 303, Chordwise Pressure Distribution, Steady, Configuration

 $C_{\mathbf{p}}$, pressure coefficient



 $C_{\rm p}$, pressure coefficient

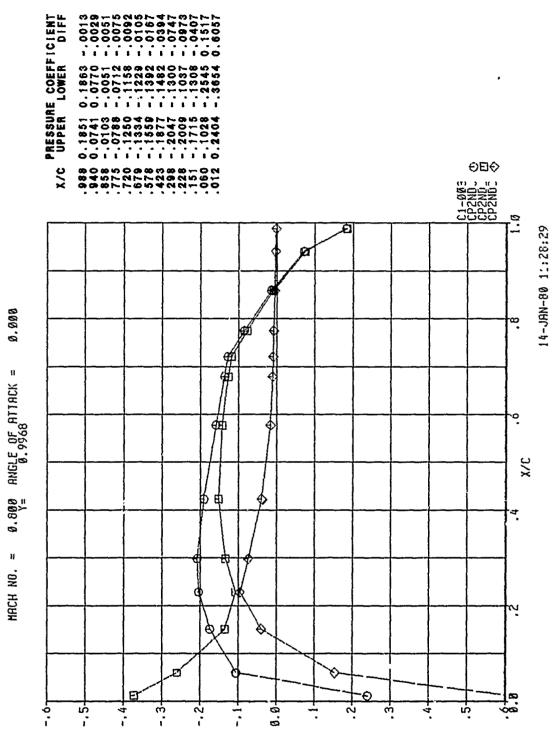


Figure 305, Chordwise Pressure Distribution, Steady, Configuration

C_p, pressure coefficient

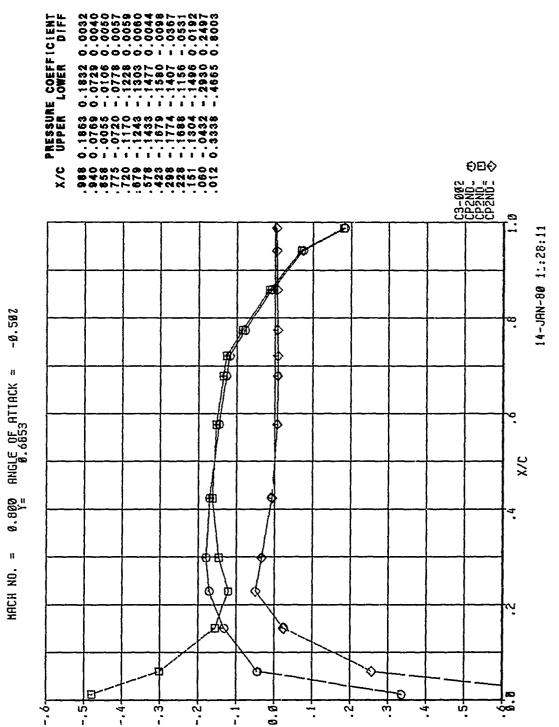
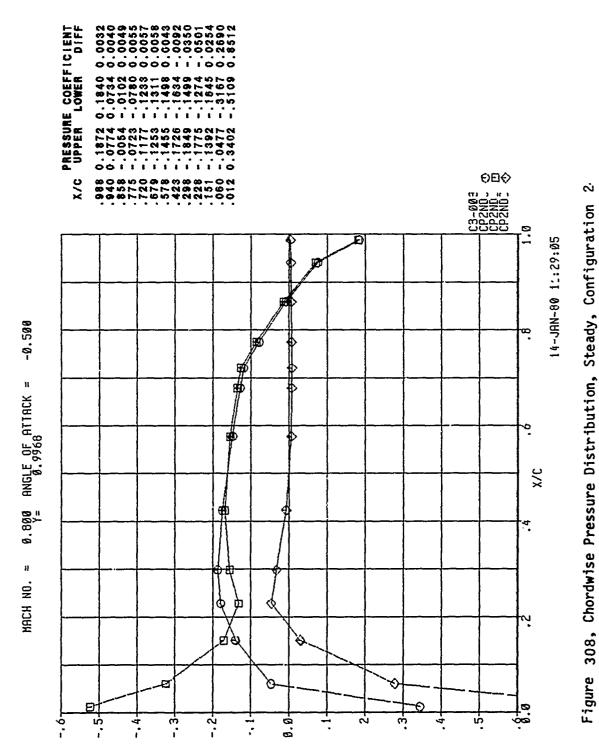


Figure 306, Chordwise Pressure Distribution, Steady, Configuration

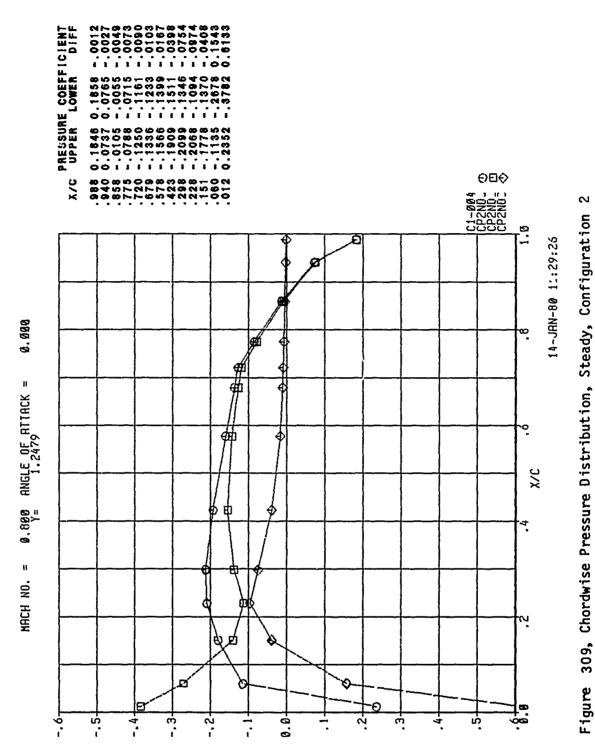
C_p, pressure coefficient

Figure 307, Chordwise Pressure Distribution, Steady, Configuration

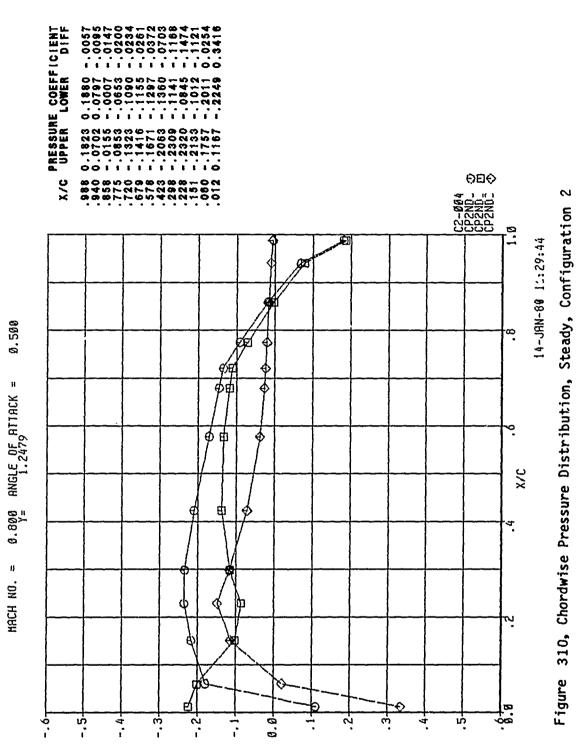
 C_{p} , pressure coefficient



C_p, pressure coefficient



 c_{p} pressure coefficient



 $c_{\rm p}$, pressure coefficient

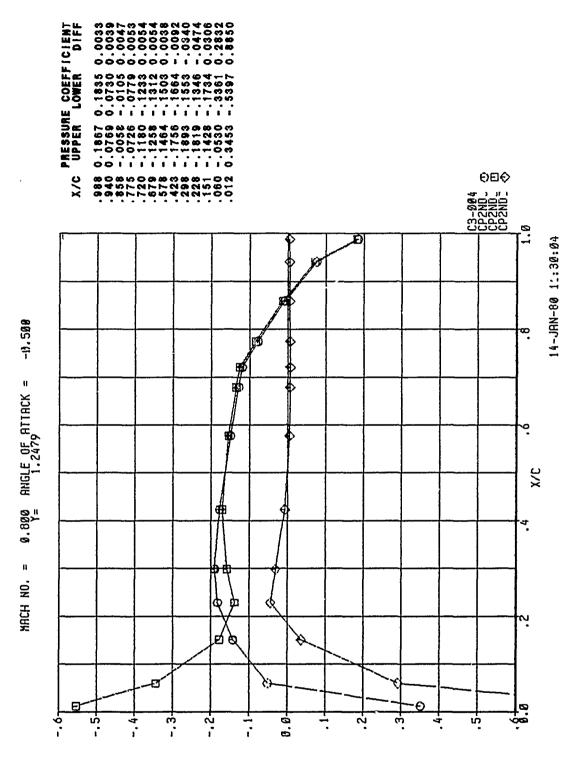
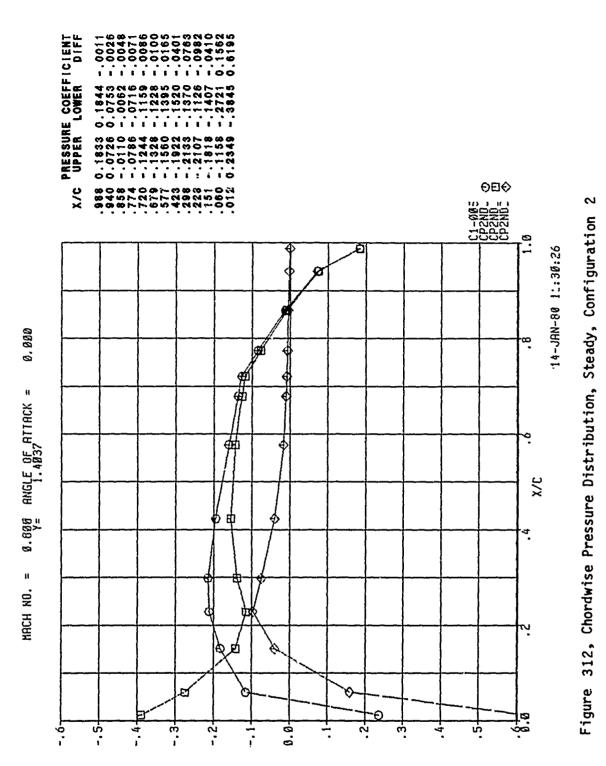
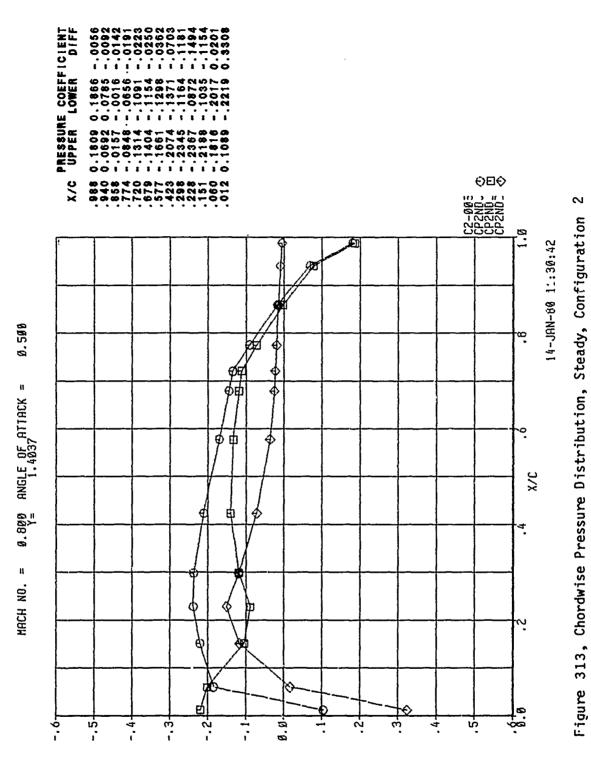


Figure 311, Chordwise Pressure Distribution, Steady, Configuration

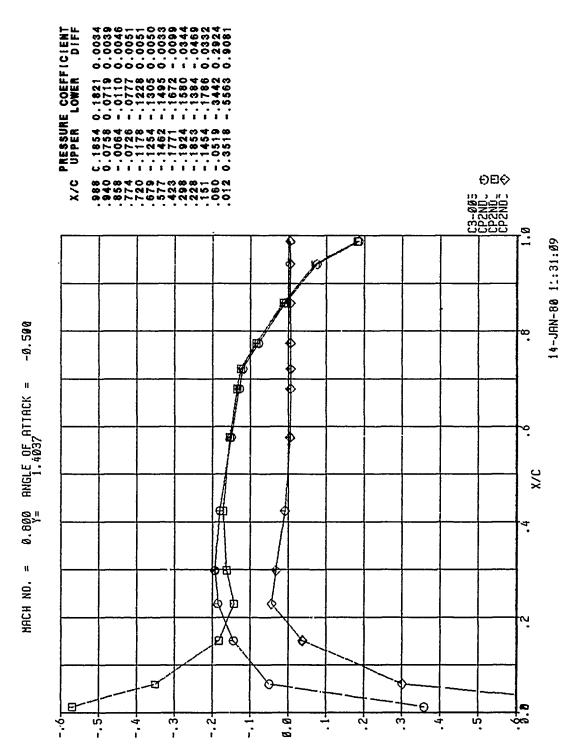
 $C_{\mathbf{p}}$, pressure coefficient



 $C_{\rm p}$, pressure coefficient



 C_{p} , pressure coefficient



Steady, Configuration

Figure 314, Chordwise Pressure Distribution,

Justoifffeoo erusserd (q^O

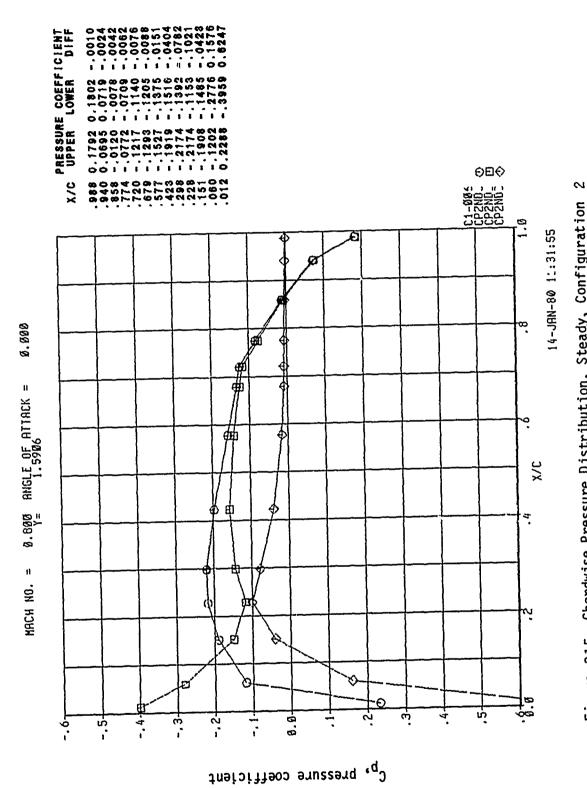


Figure 315, Chordwise Pressure Distribution, Steady, Configuration

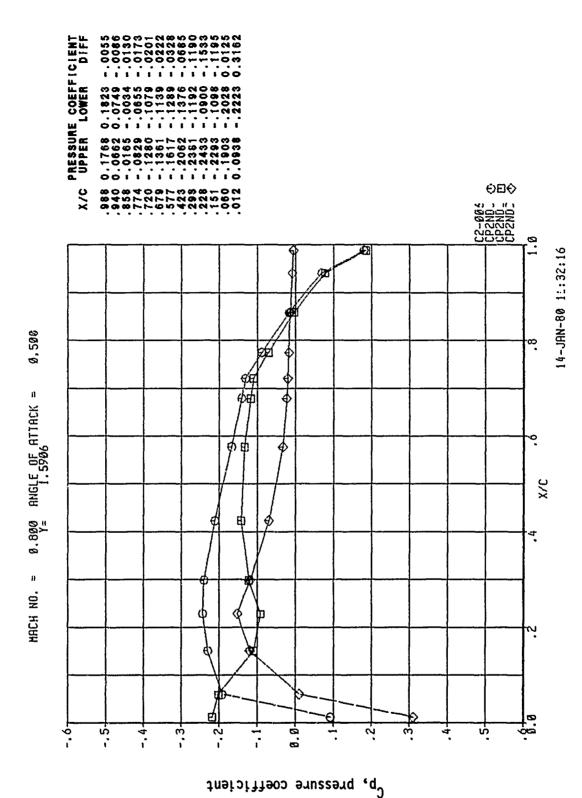


Figure 316, Chordwise Pressure Distribution, Steady, Configuration

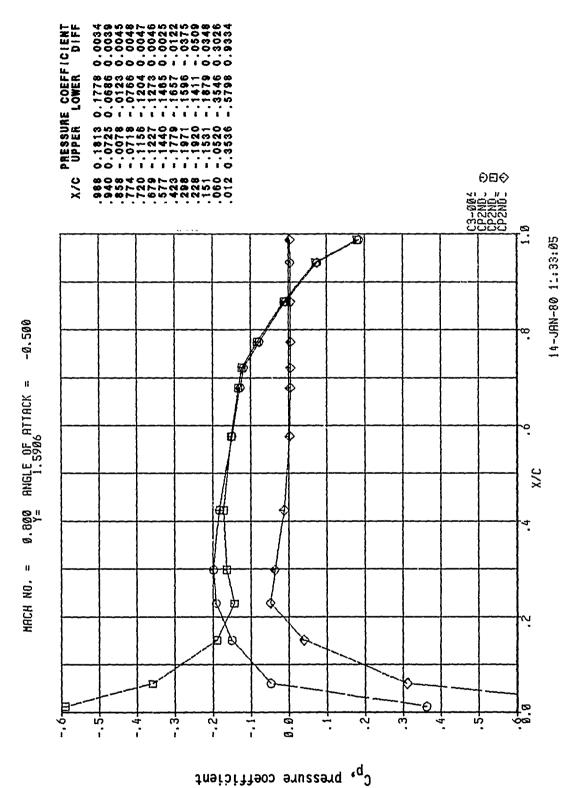


Figure 317, Chordwise Pressure Distribution, Steady, Configuration

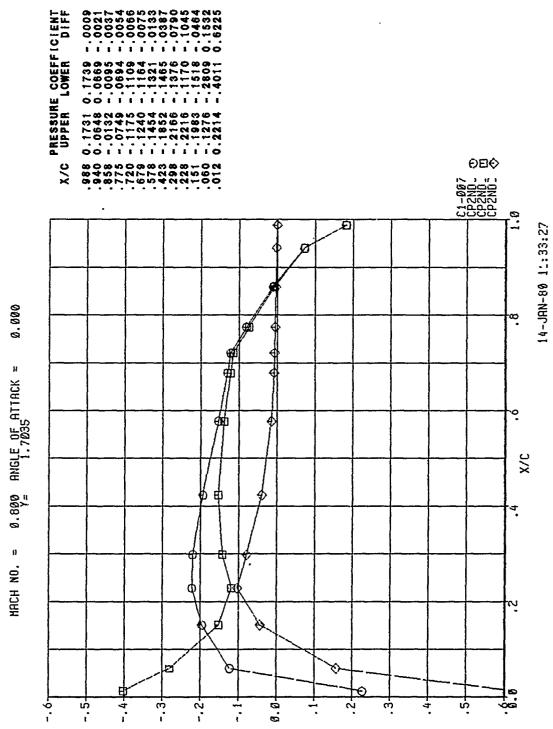
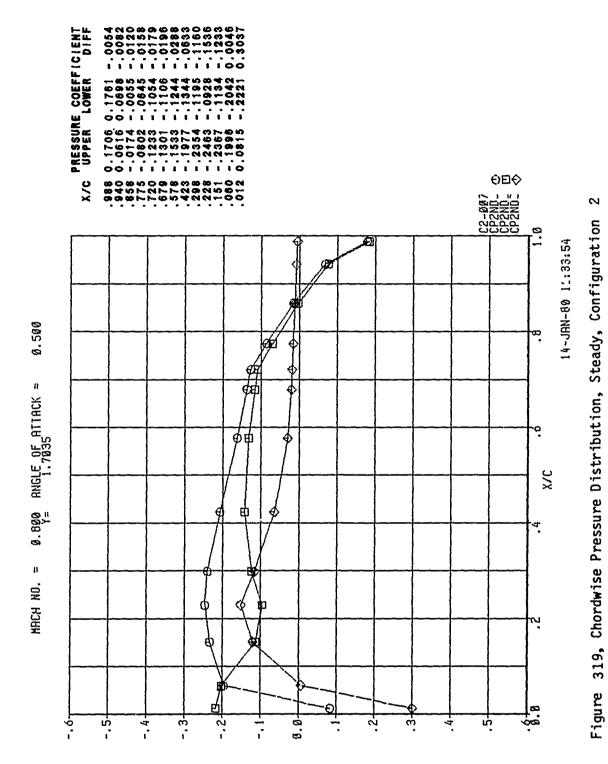


Figure 318, Chordwise Pressure Distribution, Steady, Configuration

C_p, pres_sure coefficient



 C_{p} , pressure coefficient

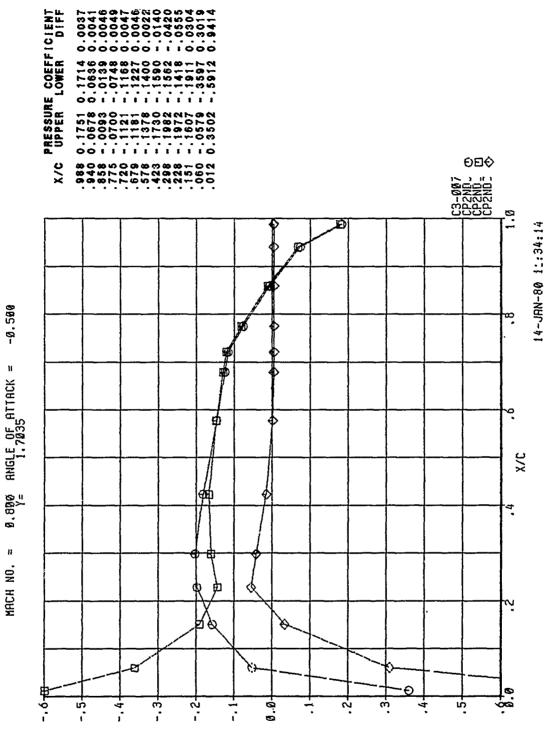
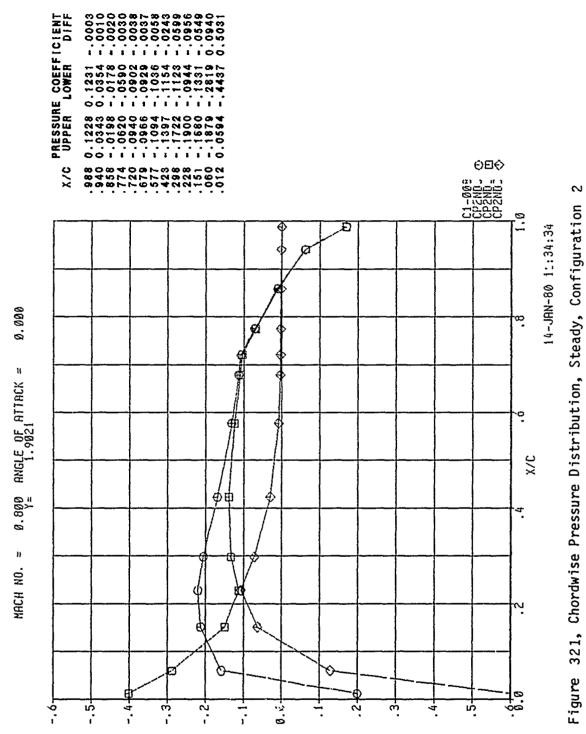


Figure 320, Chordwise Pressure Distribution, Steady, Configuration

C_p, pressure coefficient



 C_{p} , pressure coefficient

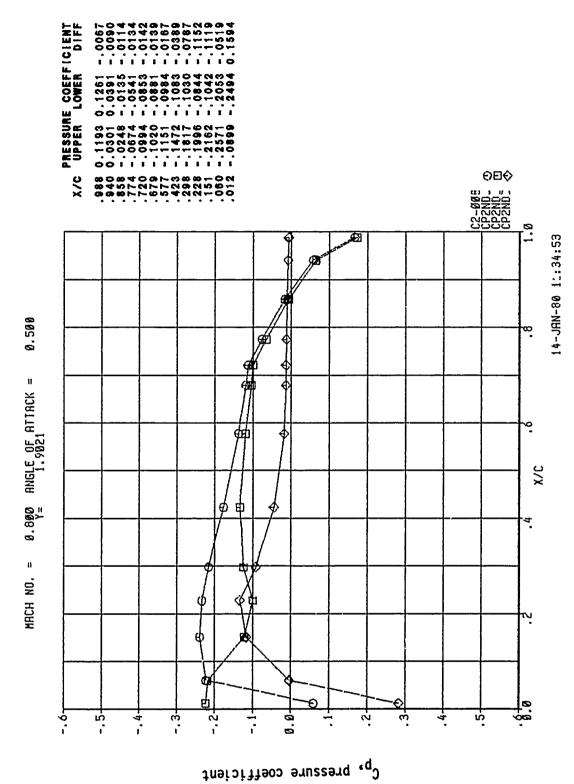


Figure 322, Chordwise Pressure Distribution, Steady, Configuration

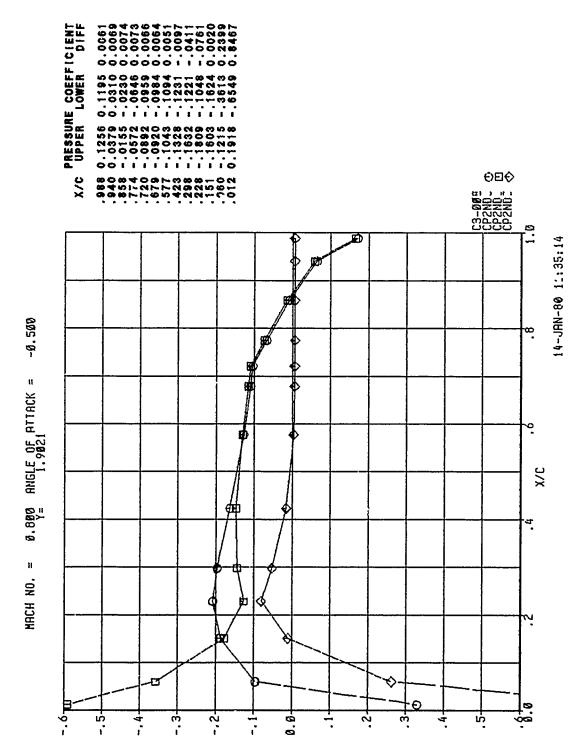
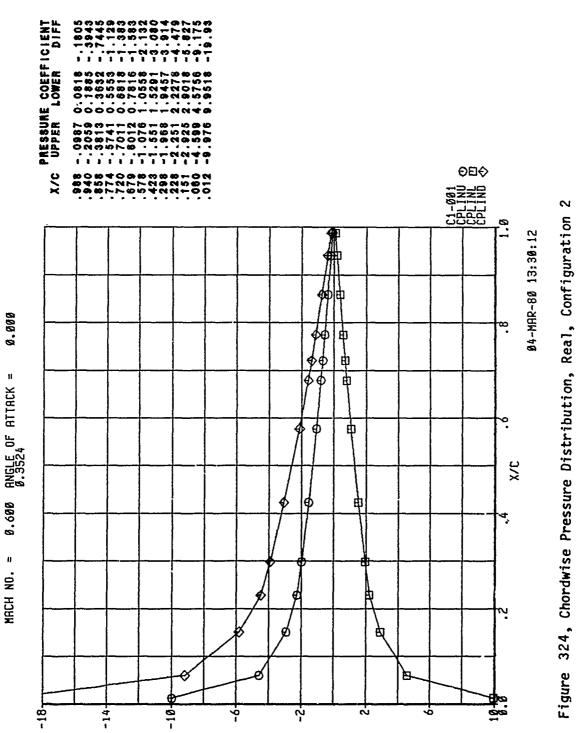


Figure 323, Chordwise Pressure Distribution, Steady, Configuration

 $C_{\mathbf{p}}$, pressure coefficient



C_p, pressure coefficient

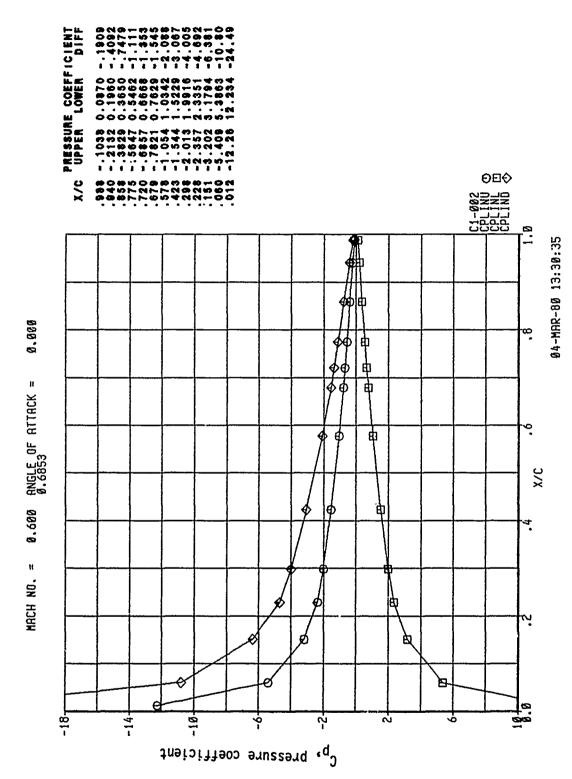


Figure 325, Chordwise Pressure Distribution, Real, Configuration

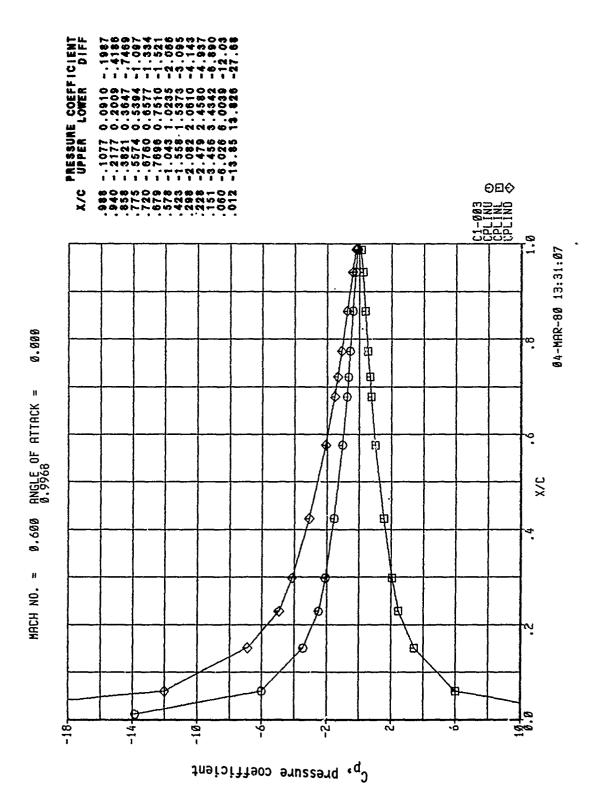


Figure 326, Chordwise Pressure Distribution, Real, Configuration 2

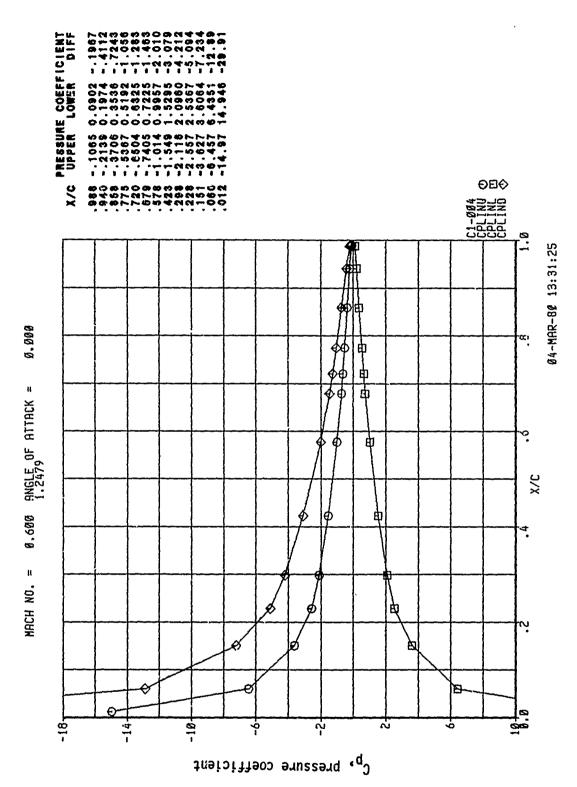


Figure 327, Chordwise Pressure Distribution, Real, Configuration 2

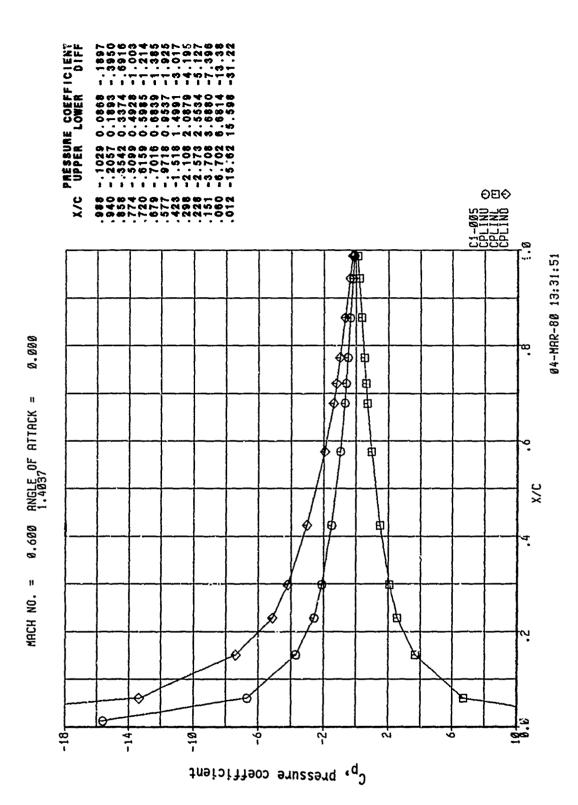


Figure 5.78, Chordwise Pressure Distribution, Real, Configuration 2

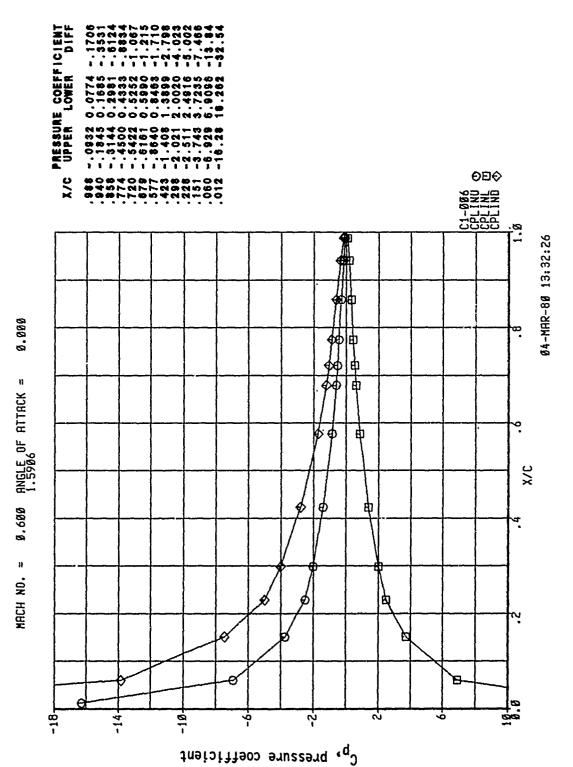


Figure 329, Chordwise Pressure Distribution, Real, Configuration 2

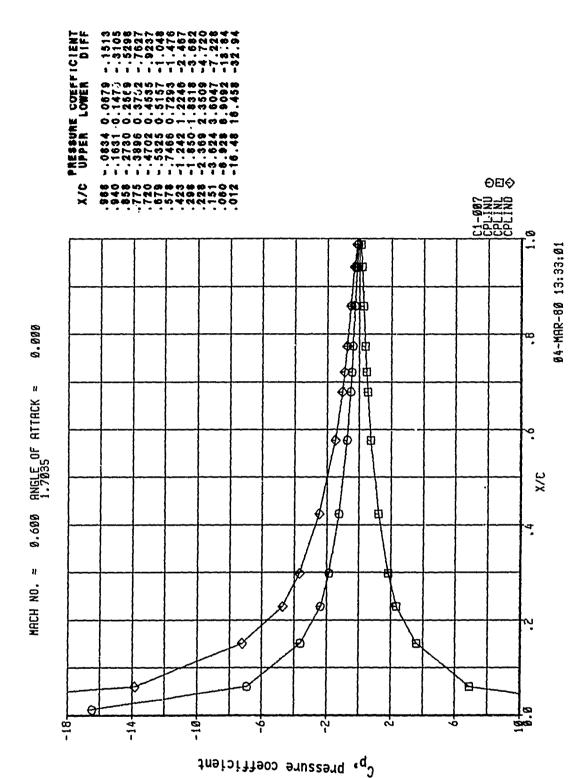


Figure 330, Chordwise Pressure Distribution, Real, Configuration 2

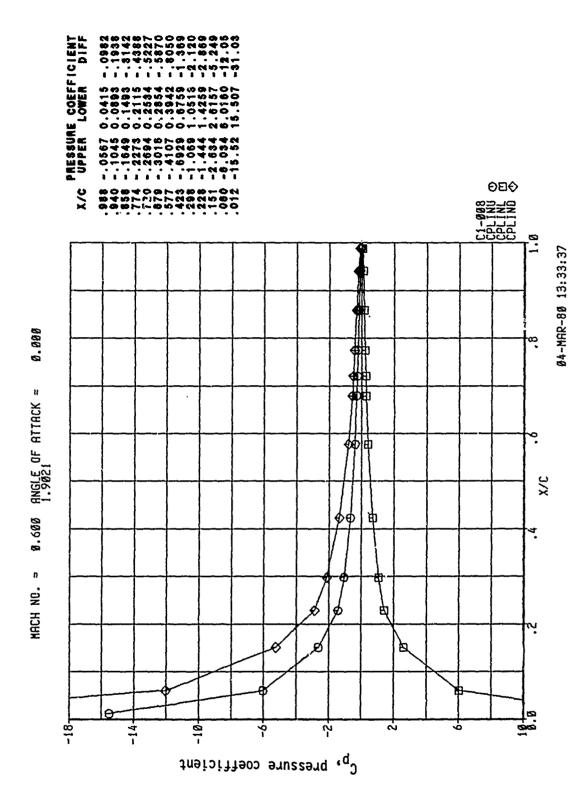


Figure 331, Chordwise Pressure Distribution, Real, Configuration 2

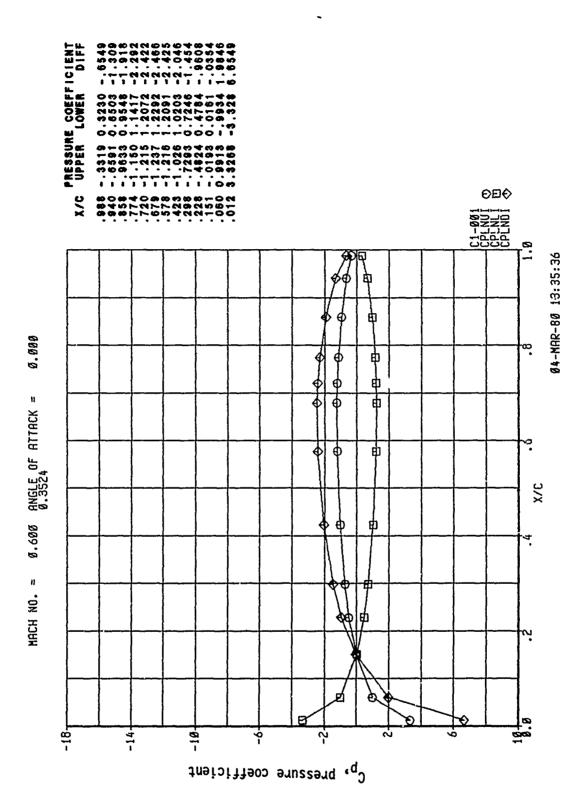
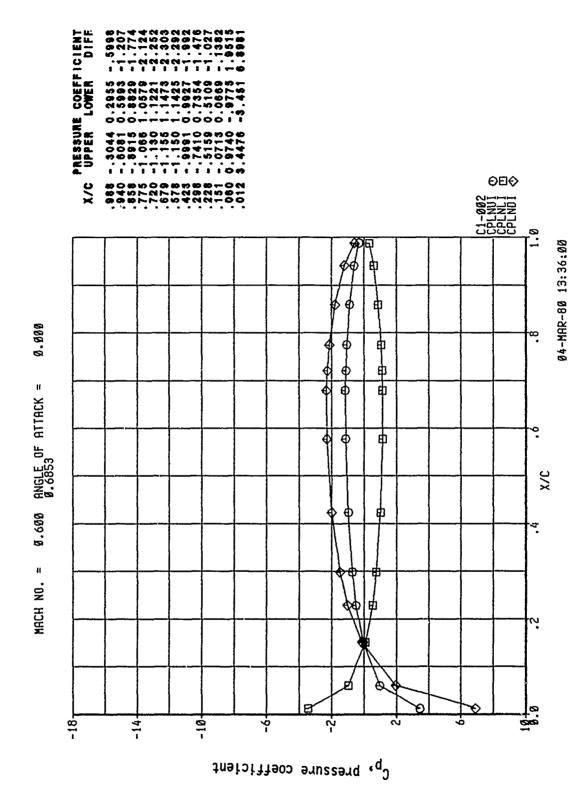


Figure 332, Chordwise Pressure Distribution, Imaginary, Configuration



N Figure 333, Chordwise Pressure Distribution, Imaginary, Configuration

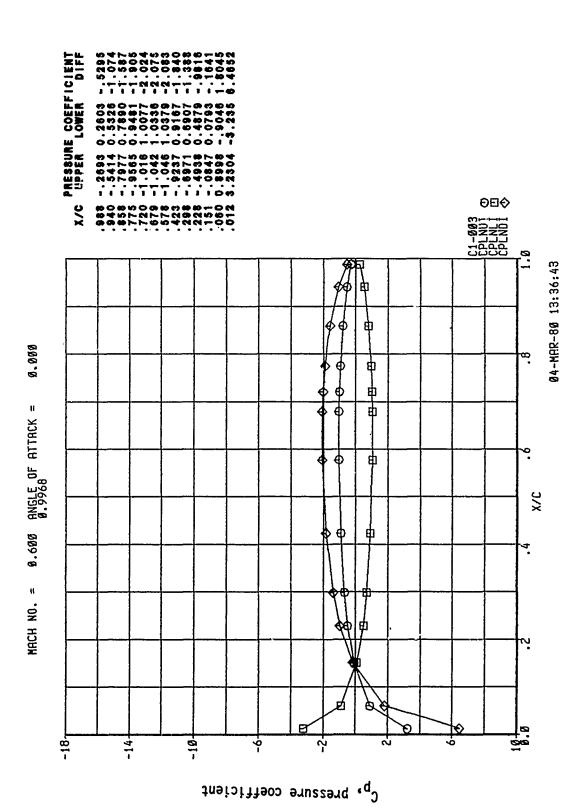


Figure 334, Chordwise Pressure Distribution, Imaginary, Configuration

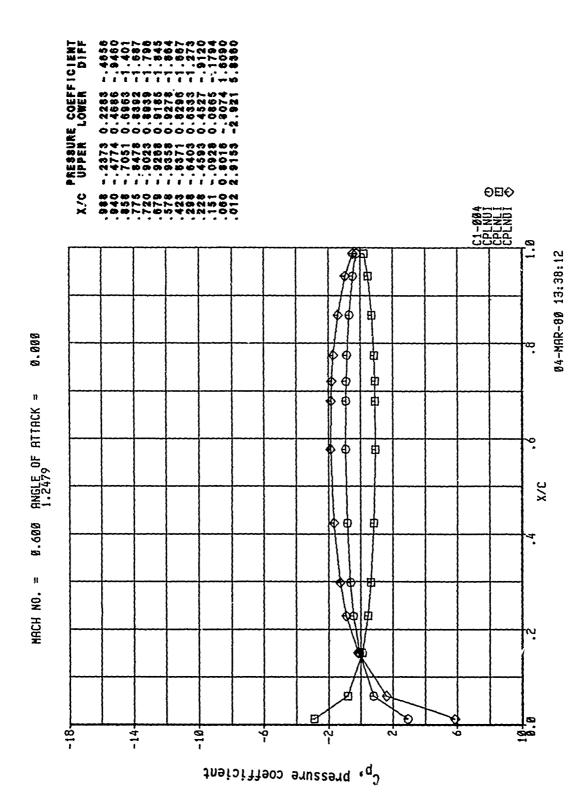


Figure 335, Chordwise Pressure Distribution, Imaginary, Configuration

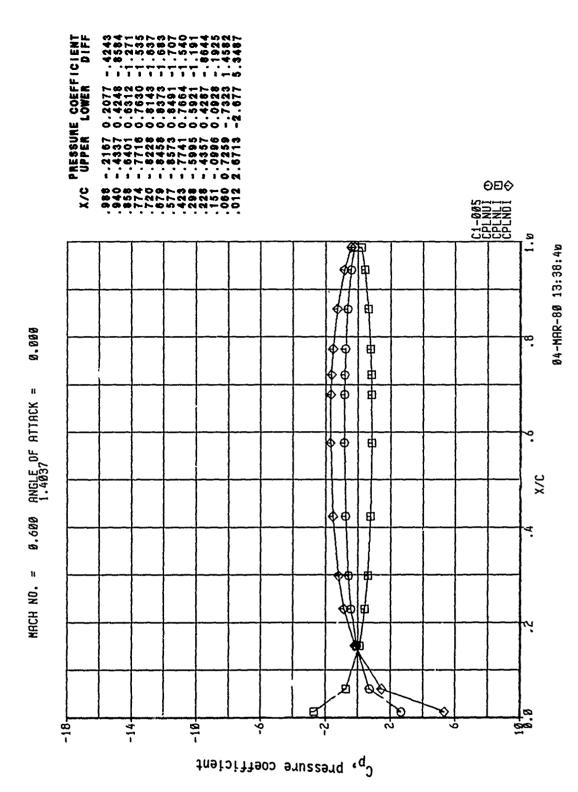
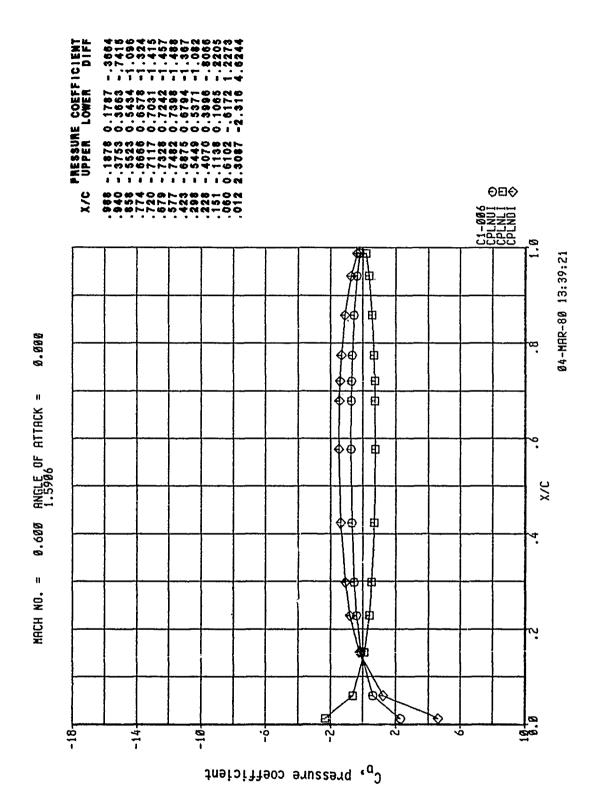


Figure 336, Chordwise Pressure Distribution, Imaginary, Configuration



337, Chordwise Pressure Distribution, Imaginary, Configuration

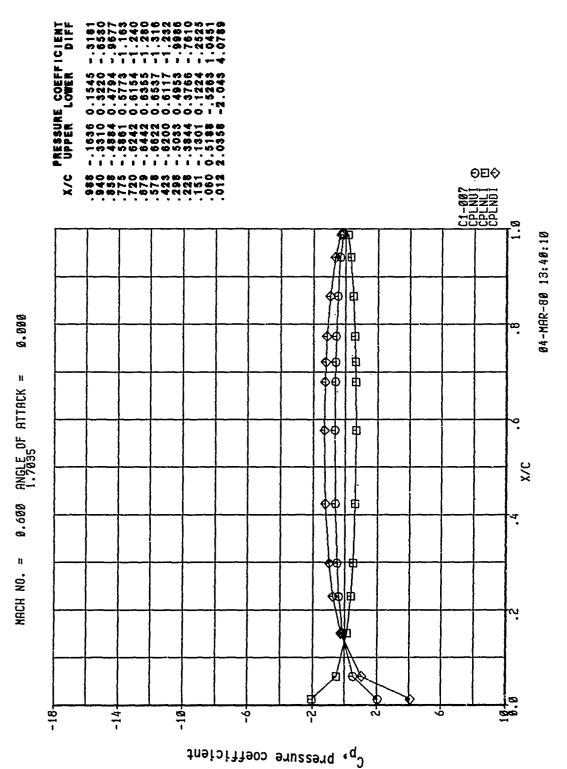


Figure 338, Chordwise Pressure Distribution, Imaginary, Configuration 2

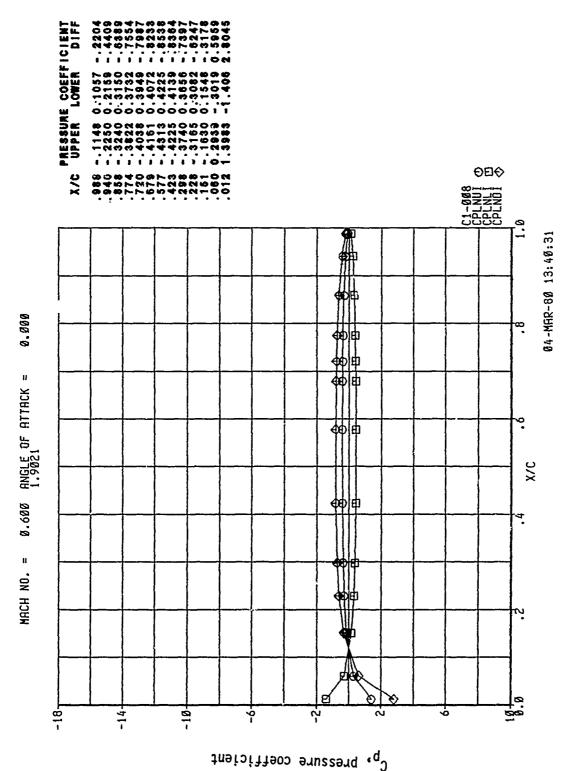


Figure 339, Chordwise Pressure Distribution, Imaginary, Configuration 2

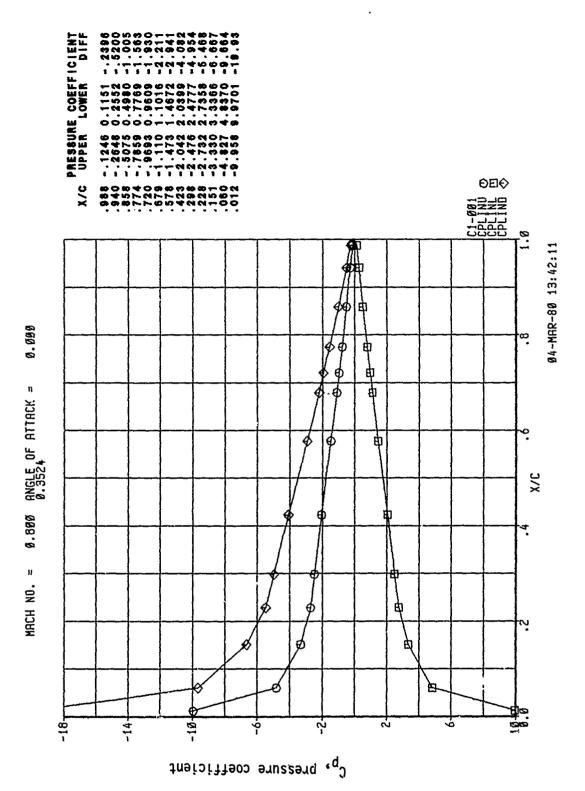


Figure 340, Chordwise Pressure Distribution, Imaginary, Configuration

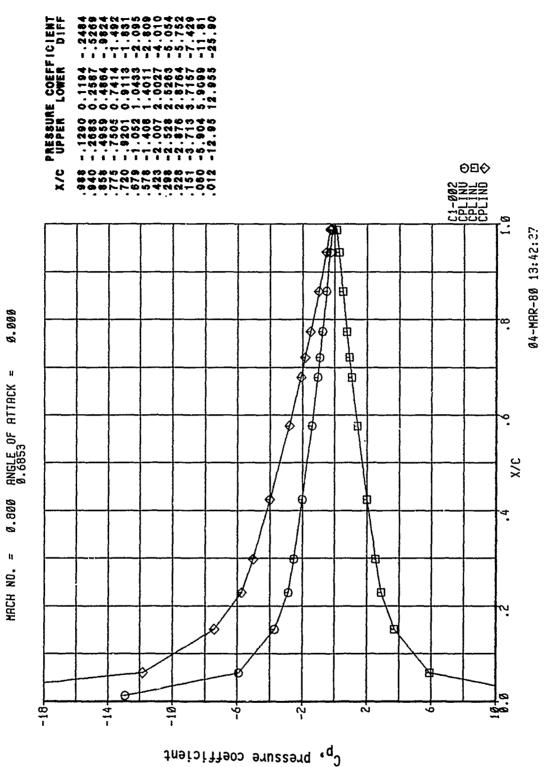


Figure 341, Chordwise Pressure Distribution, Imaginary, Configuration

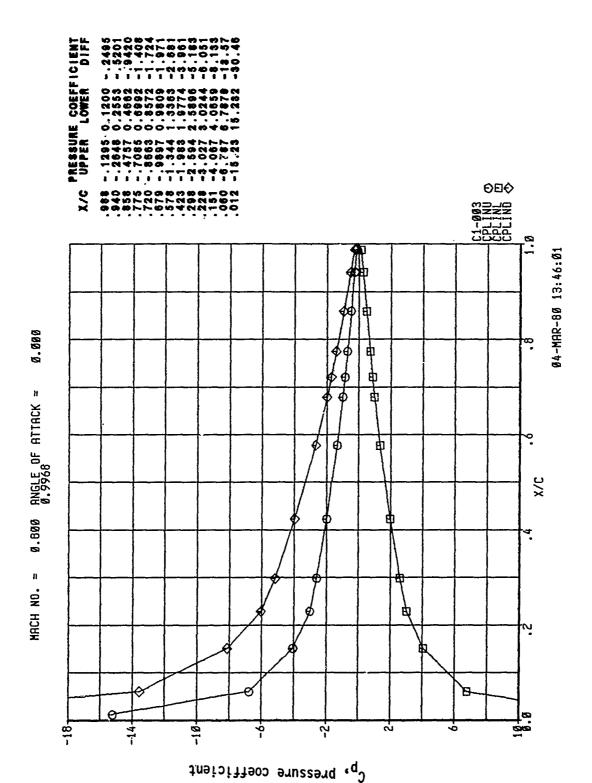


Figure 342, Chordwise Pressure Distribution, Real, Configuration 2

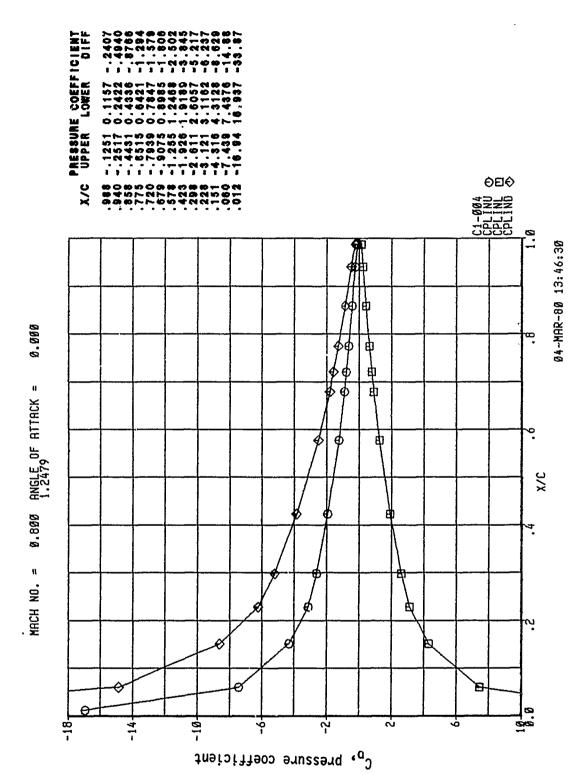


Figure 343, Chordwise Pressure Distribution, Real, Configuration

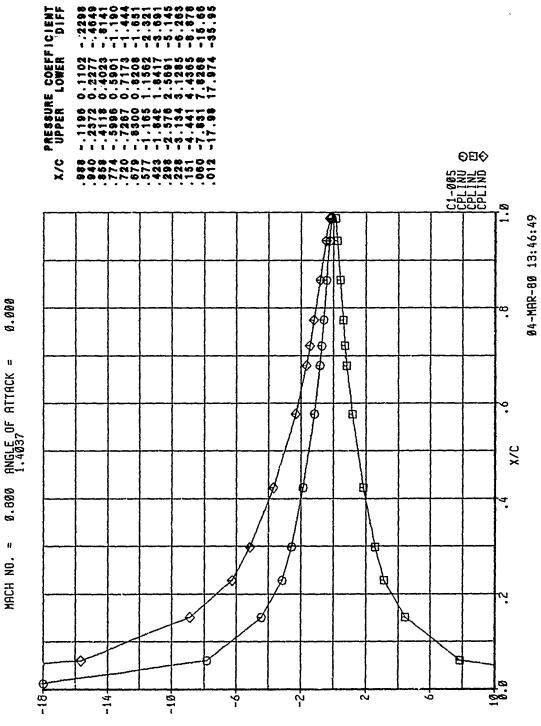


Figure 344, Chordwise Pressure Distribution, Real, Configuration

. Dressure coefficient

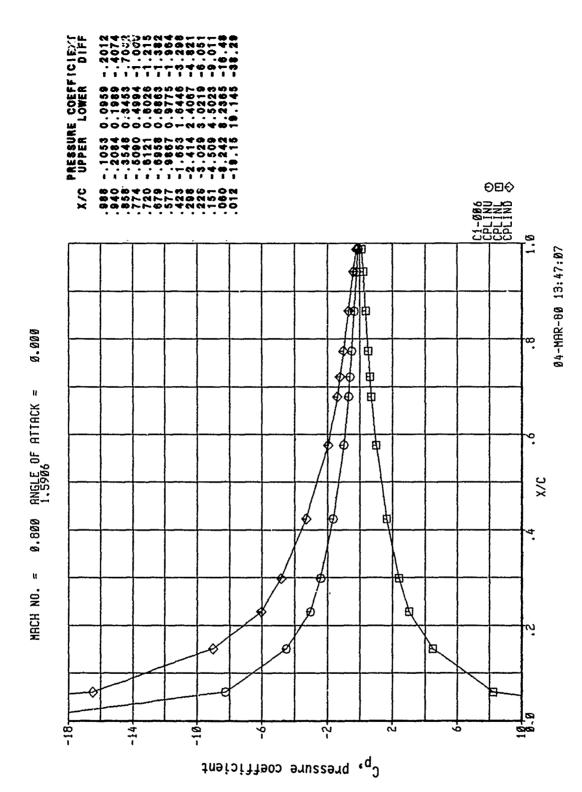


Figure 345, Chordwise Pressure Distribution, Real, Configuration

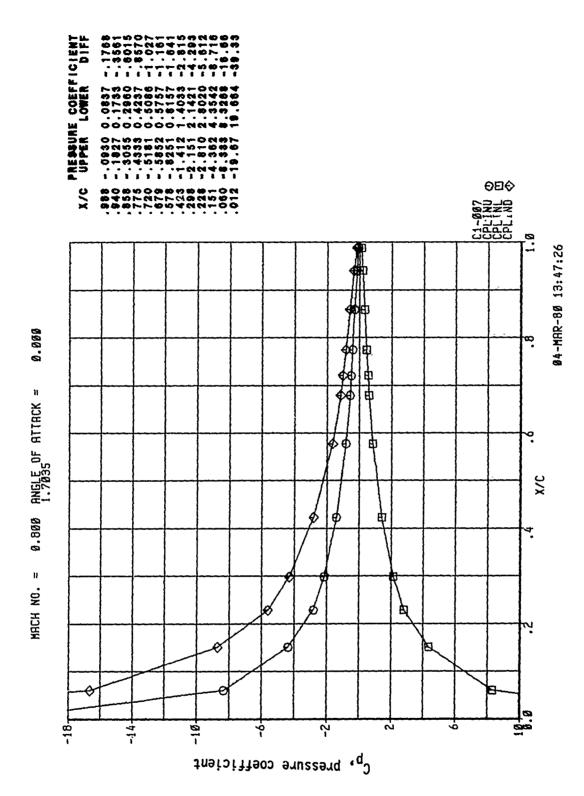


Figure 346, Chordwise Pressure Distribution, Real, Configuration 2

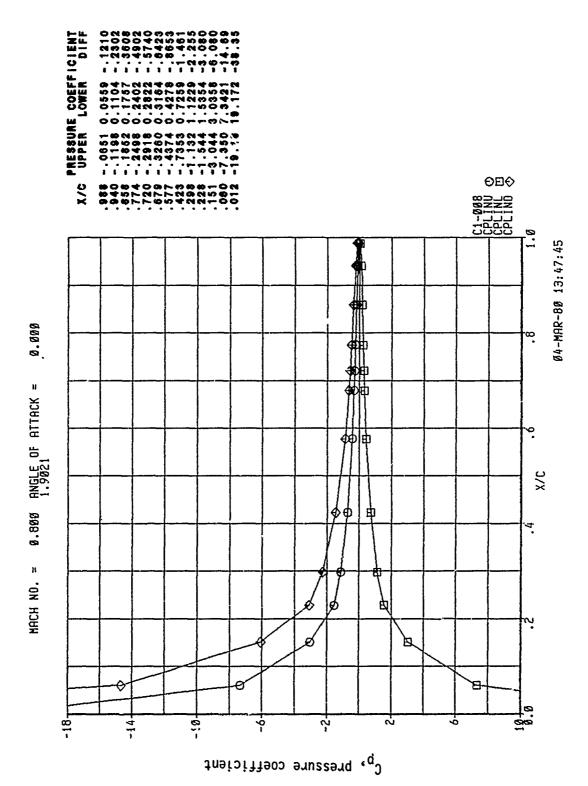


Figure 347, Chordwise Pressure Distribution, Real, Configuration 2

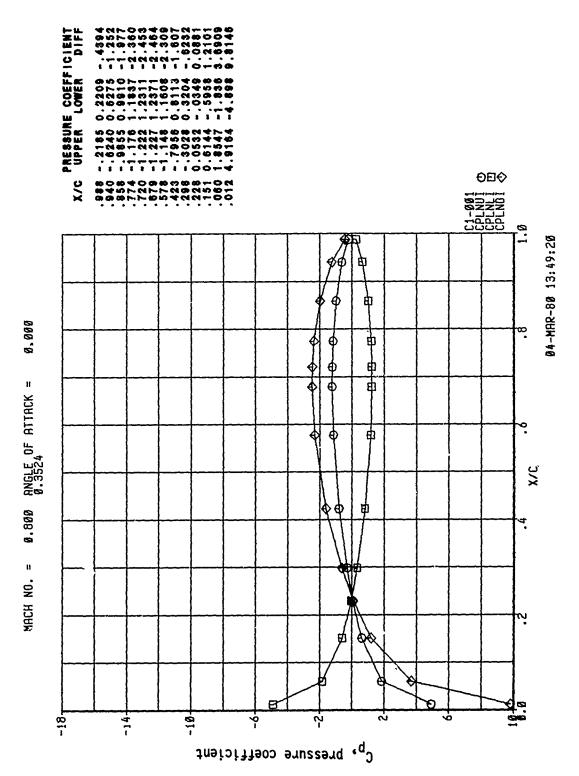


Figure 348, Chordwise Pressure Distribution, Imaginary, Configuration 2

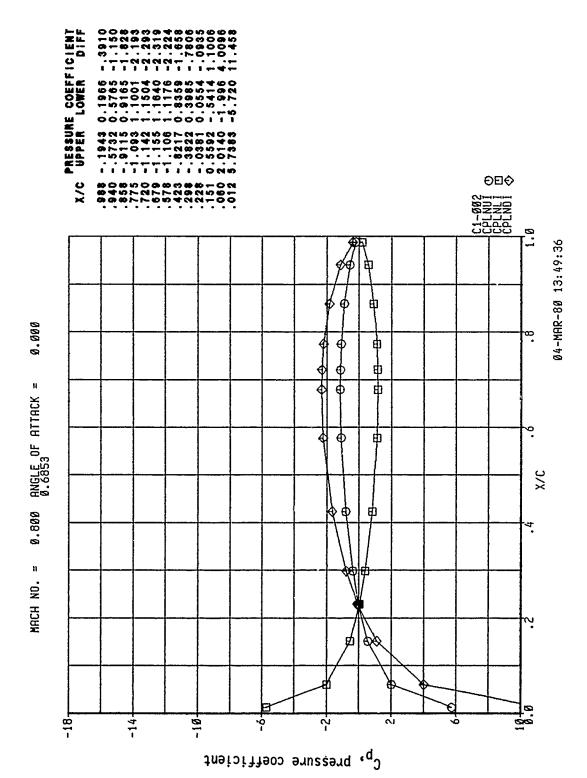


Figure 349, Chordwise Pressure Distribution, Imaginary, Configuration

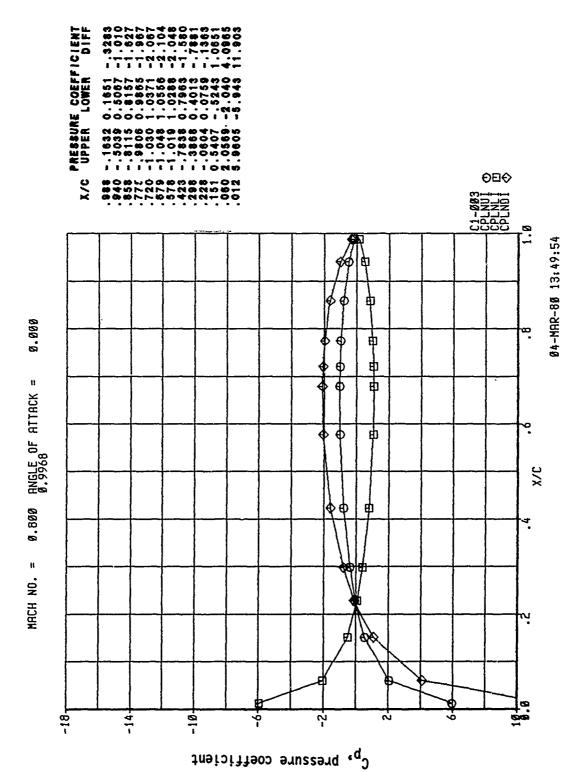


Figure 350, Chordwise Pressure Distribution, Imaginary, Configuration

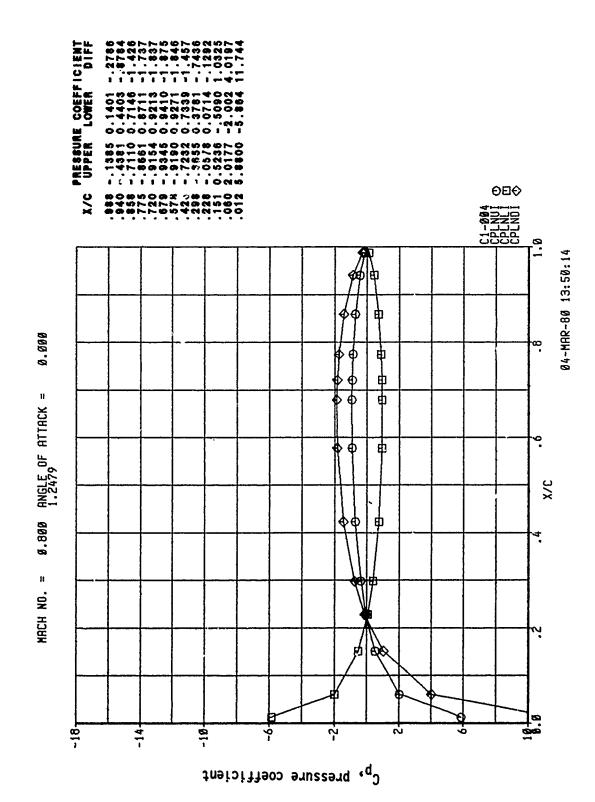


Figure 351, Chordwise Pressure Distribution, Imaginary, Configuration

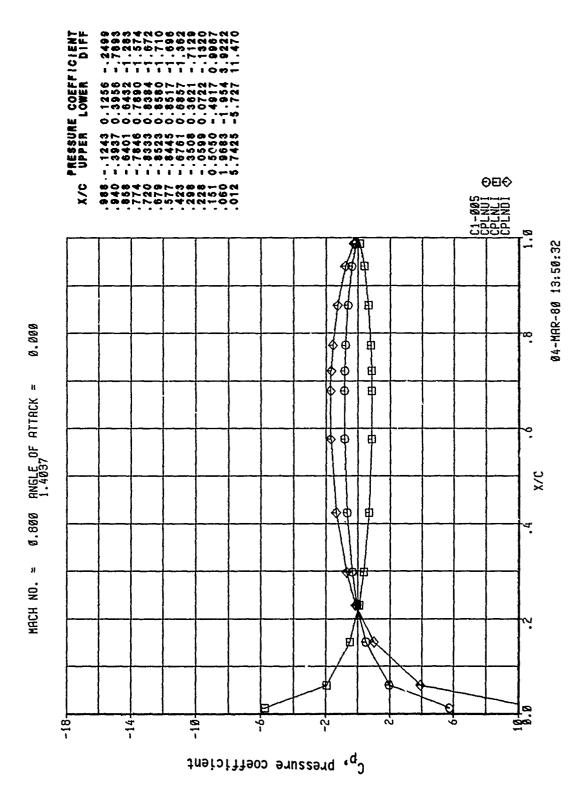
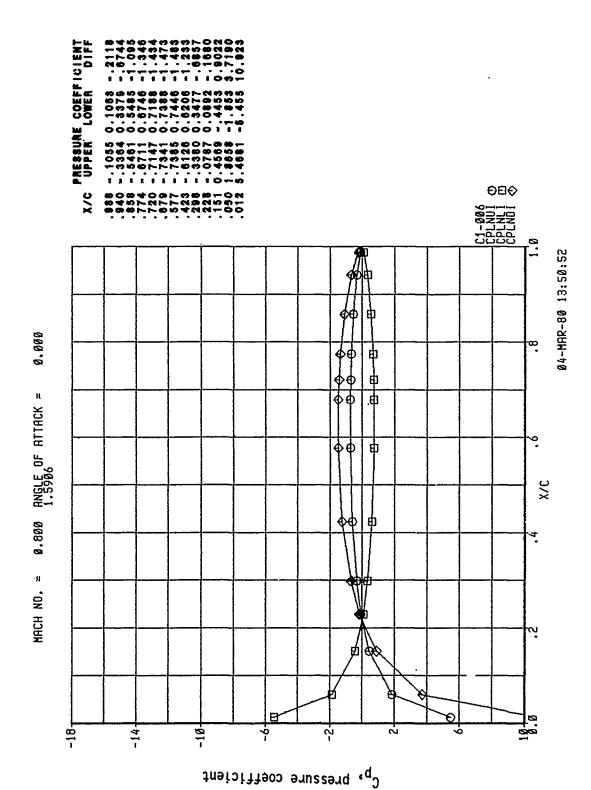


Figure 352, Chordwise Pressure Distribution, Imaginary, Configuration

.



aninillenn amuzzamu ...

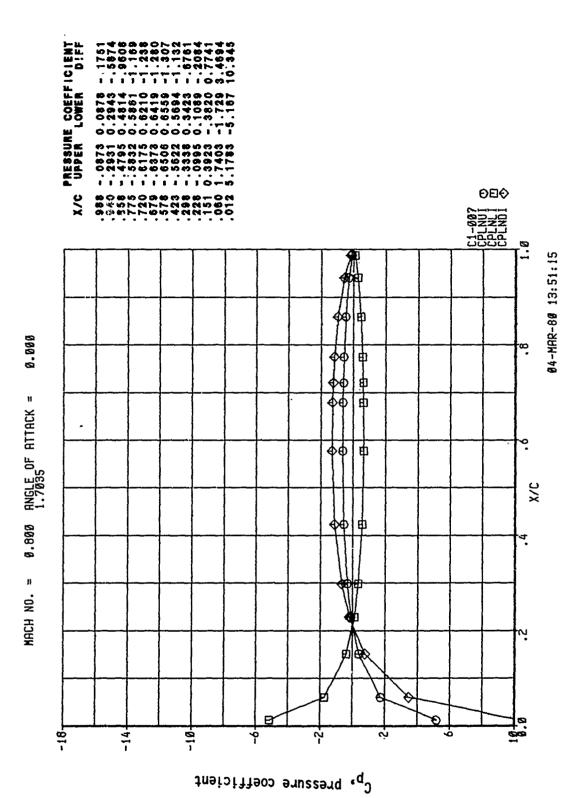


Figure 354, Chordwise Pressure Distribution, Imaginary, Configuration

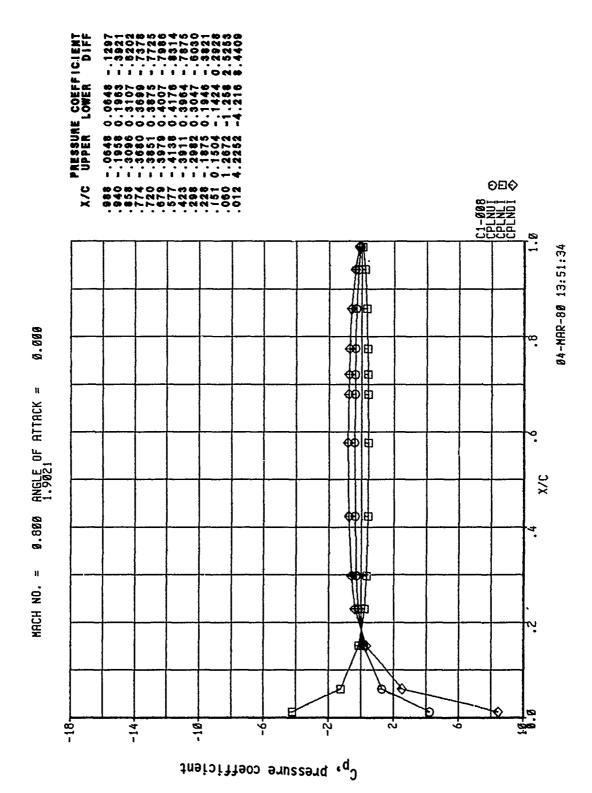
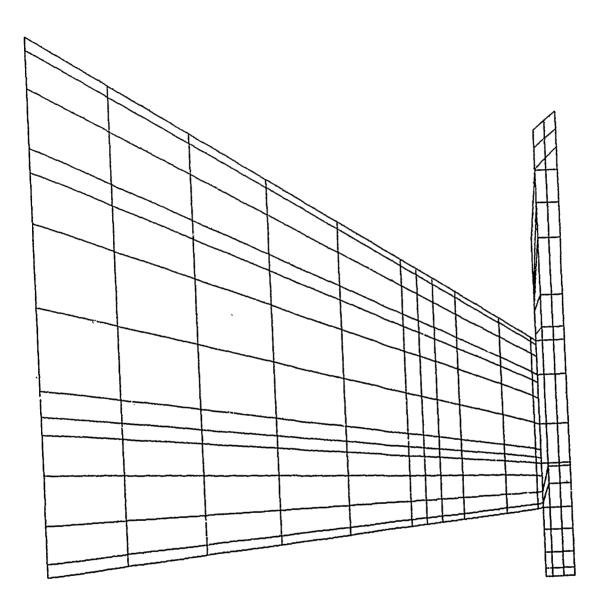


Figure 355, Chordwise Pressure Distribution, Imaginary, Configuration



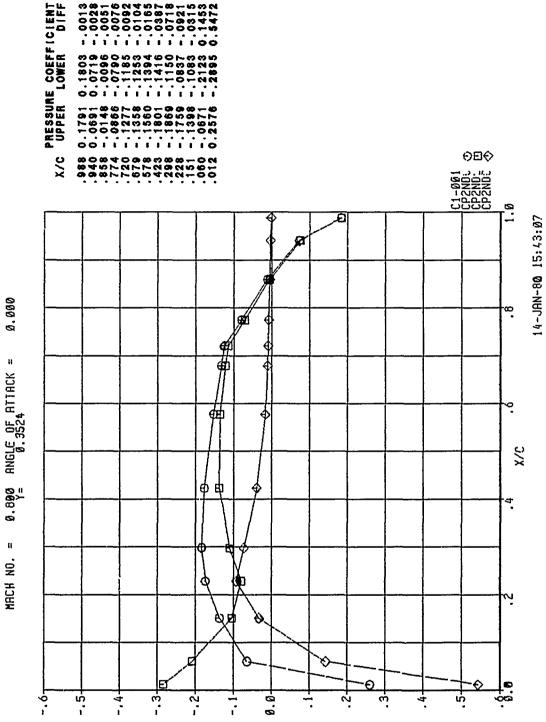


Figure 357, Chordwise Pressure Distribution, Steady, Configuration

fig. pressure coefficient

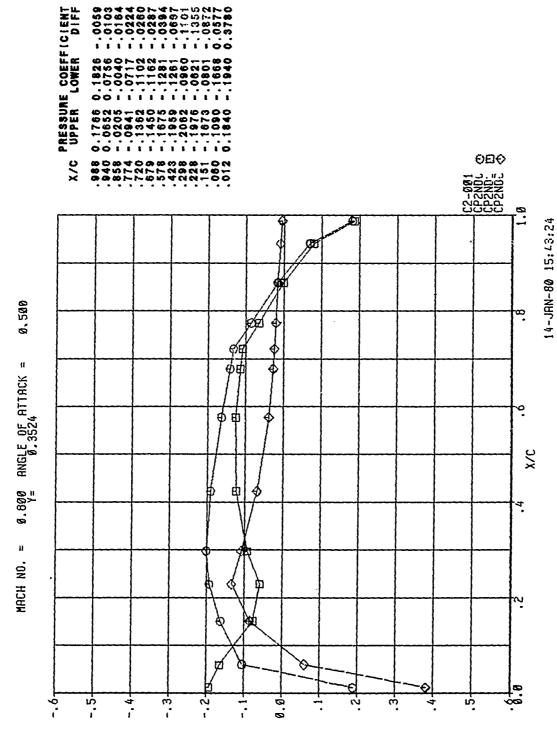


Figure 358, Chordwise Pressure Distribution, Steady, Configuration 3'

 σ_{p} , pressure coefficient

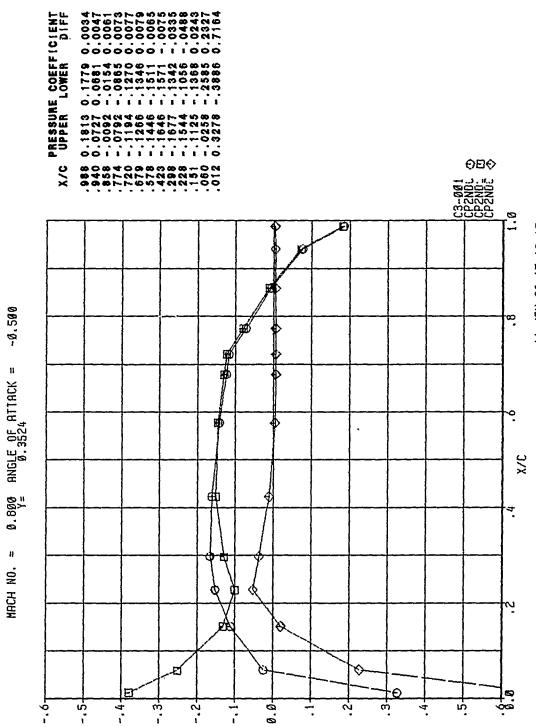


Figure 359, Chordwise Pressure Distribution, Steady, Configuration

C_p, pressure coefficient

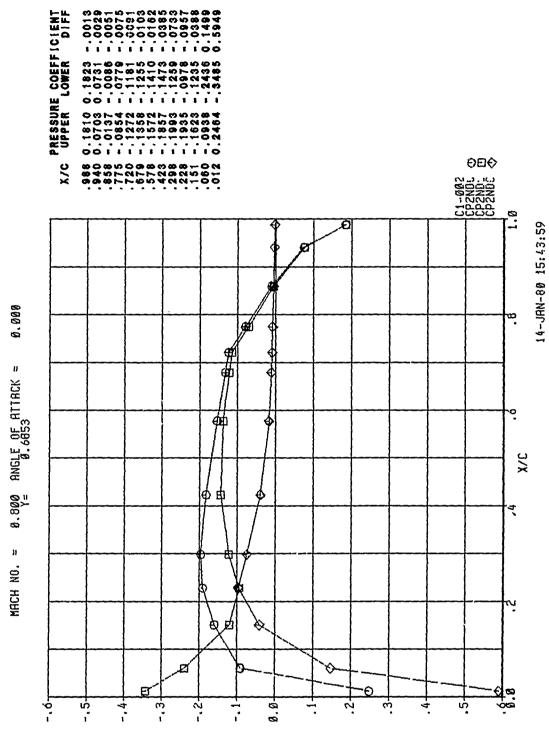


Figure 360, Chordwise Pressure Distribution, Steady, Configuration 3

 $C_{\rm p}$, pressure coefficient

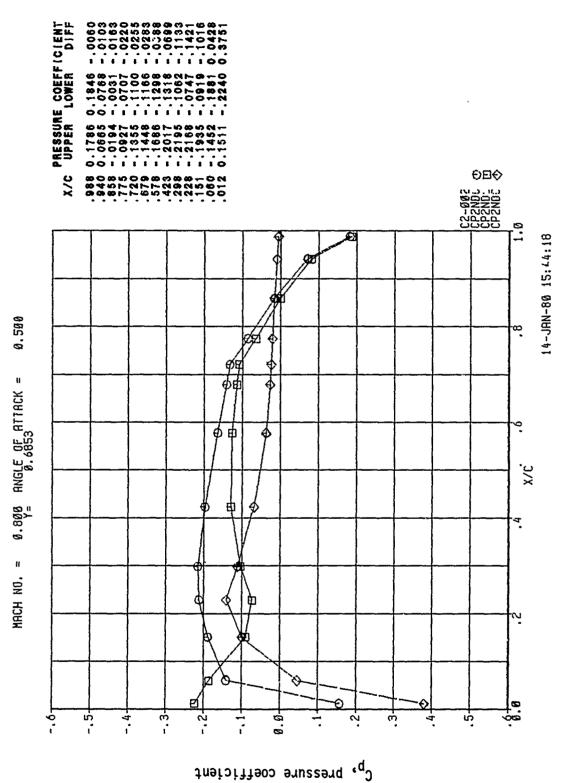


Figure 361, Chordwise Pressure Distribution, Steady, Configuration

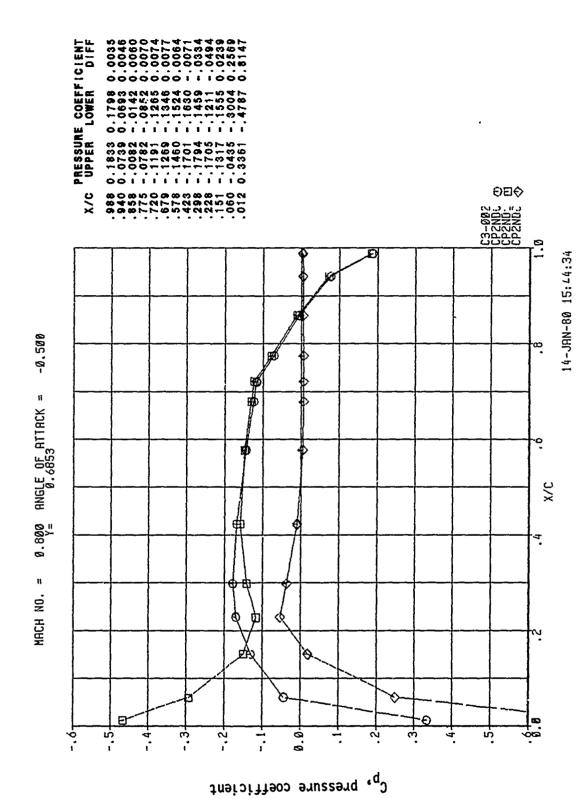


Figure 362, Chordwise Pressure Distribution, Steady, Configuration 3

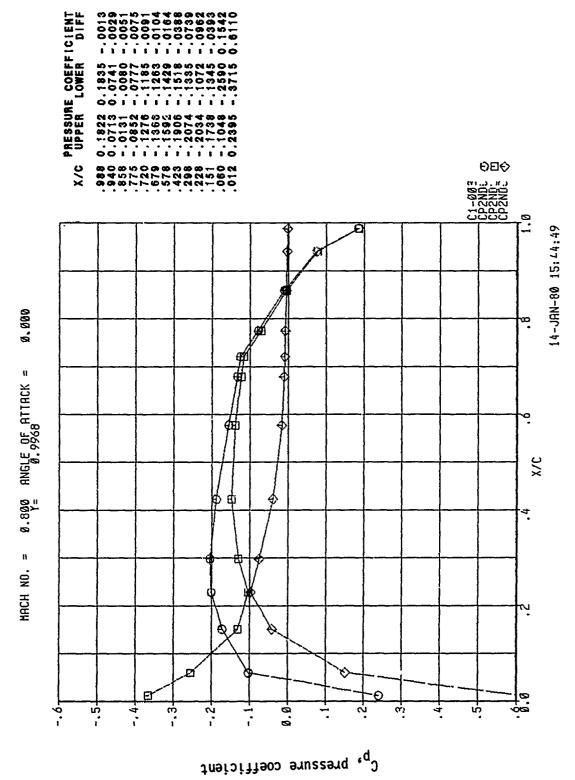
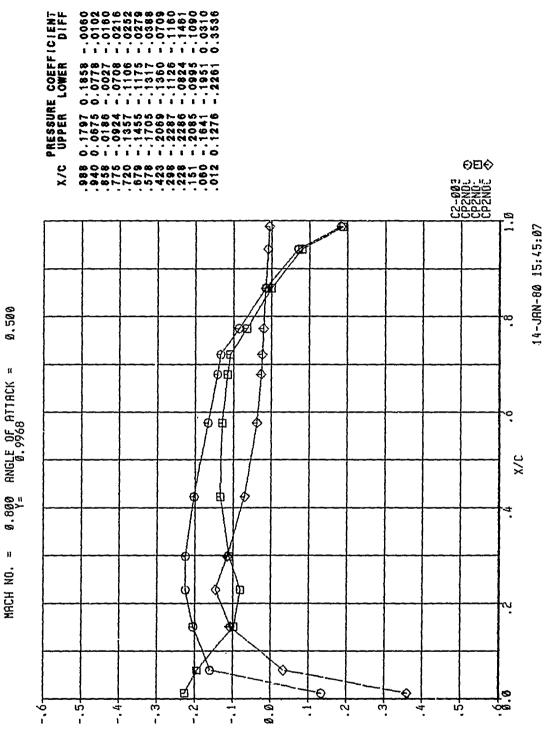


Figure 363, Chordwise Pressure Distribution, Steady, Configuration



1

Figure 364, Chordwise Pressure Distribution, Steady, Configuration 3

 $\sigma_{\rm p}$ pressure coefficient

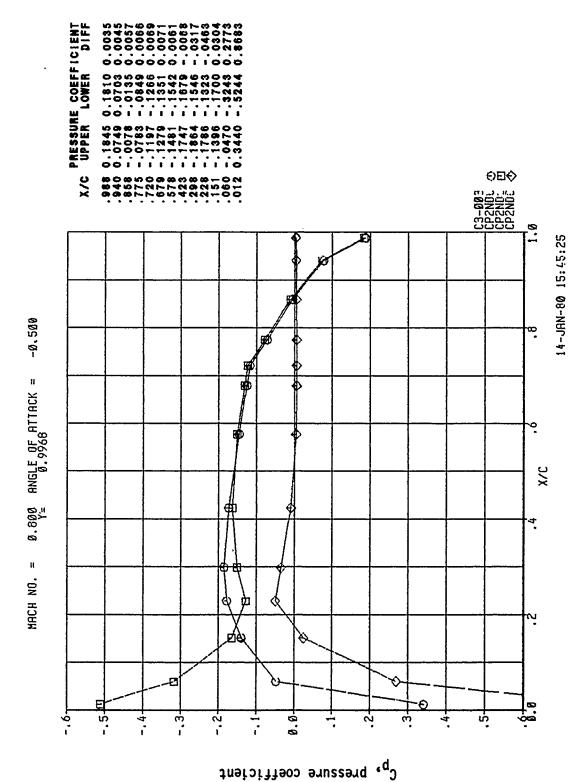


Figure 365, Chordwise Pressure Vistribution, Steady, Configuration 3

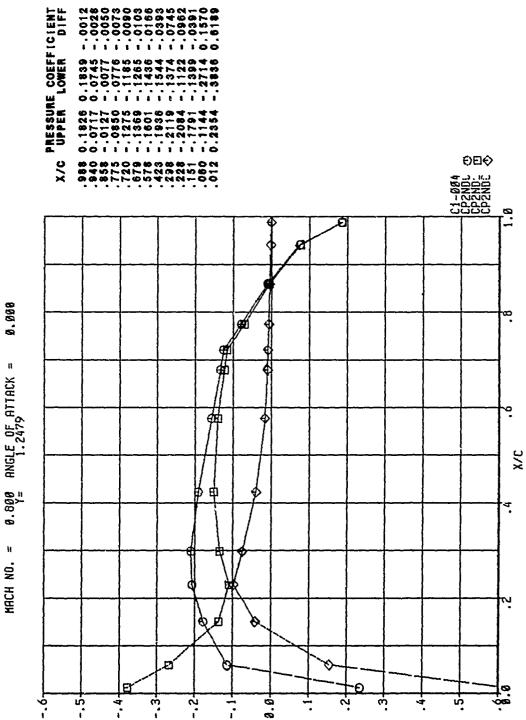


Figure 366, Chordwise Pressure Distribution, Steady, Configuration 3

14-JRN-80 15:45:42

 $C_{\mathbf{p}}$, pressure coefficient

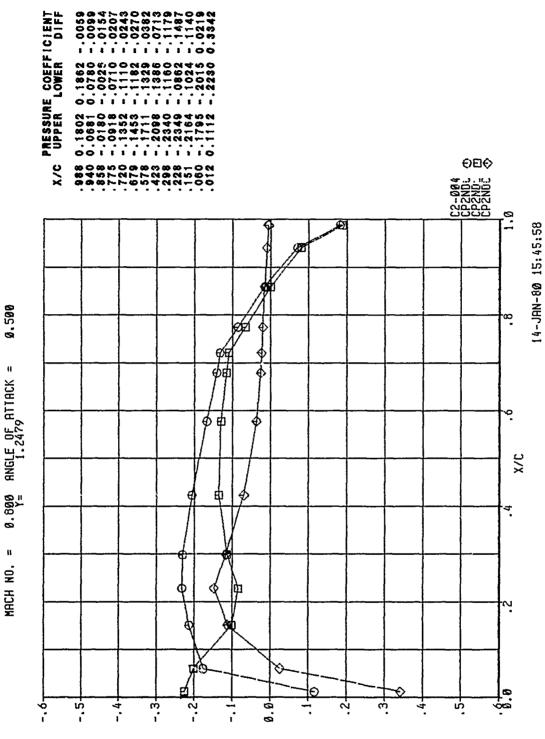


Figure 367, Chordwise Pressure Distribution, Steady, Configuration

 $c_{
m p}$, pressure coefficient

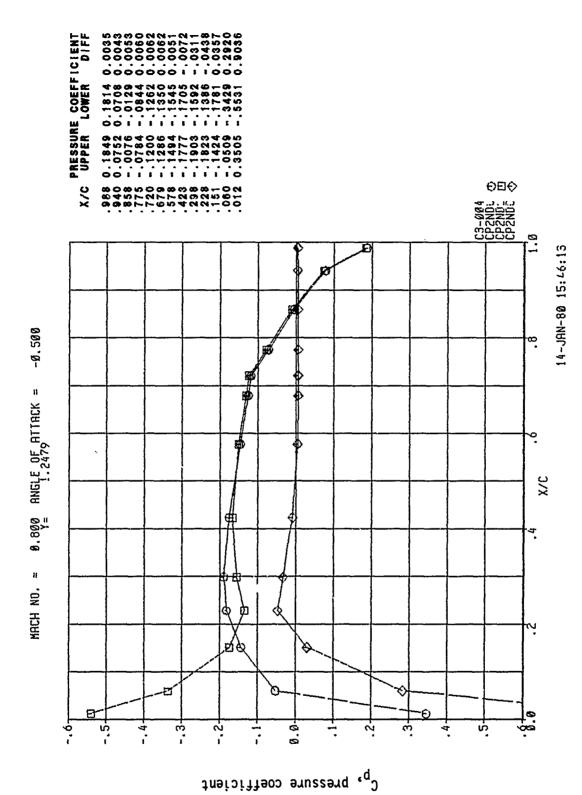


Figure 368, Chordwise Pressure Distribution, Steady, Configuration 3

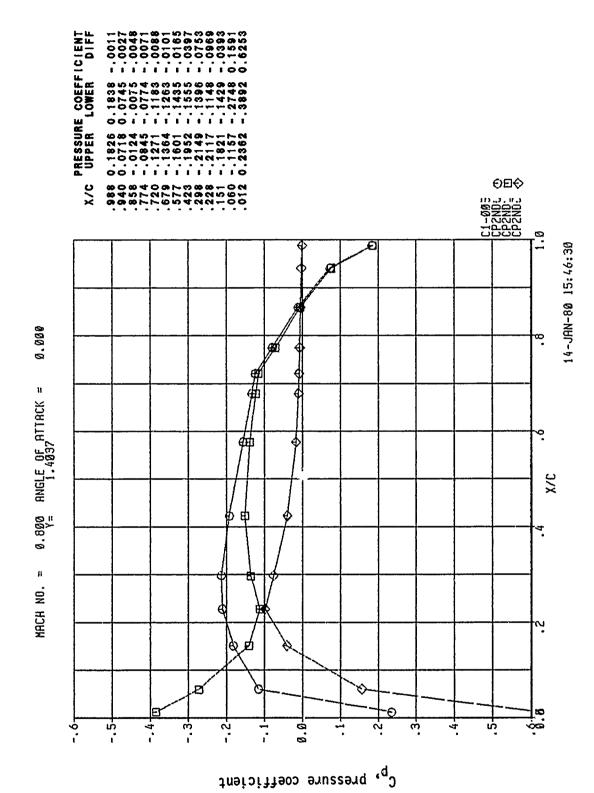


Figure 369, Chordwise Pressure Distribution, Steady, Configuration

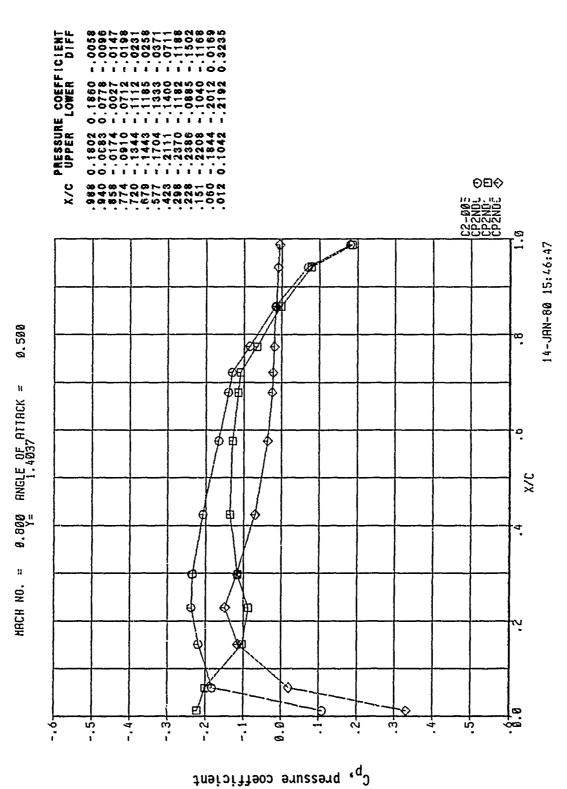


Figure 370, Chordwise Pressure Distribution, Steady, Configuration 3

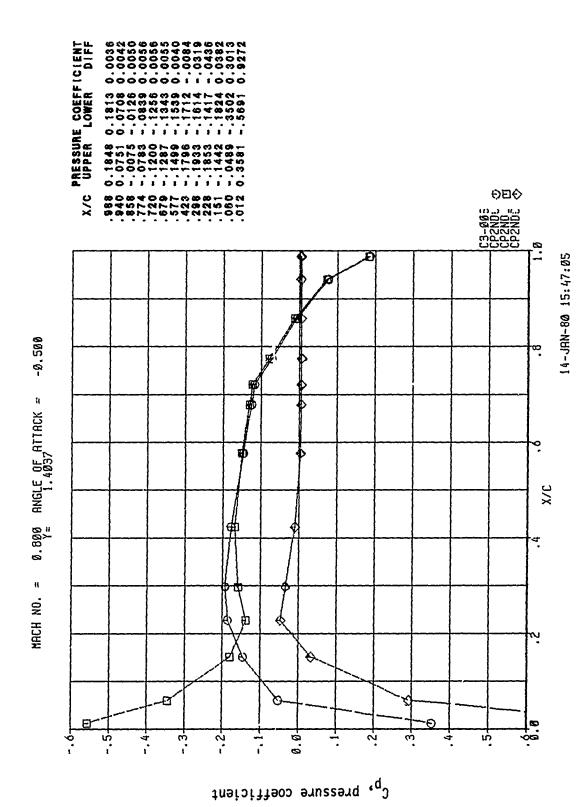


Figure 371, Chordwise Pressure Distribution, Steady, Configuration 3

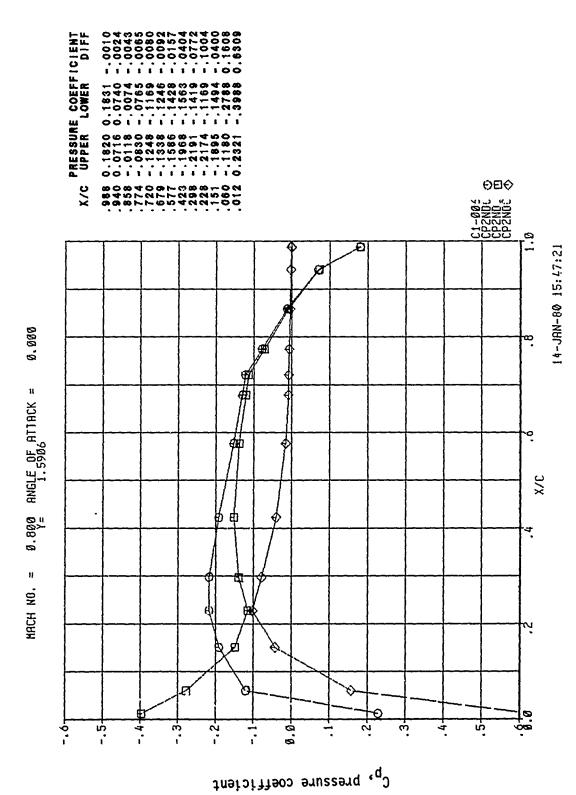


Figure 372, Chordwise Pressure Distribution, Steady, Configuration

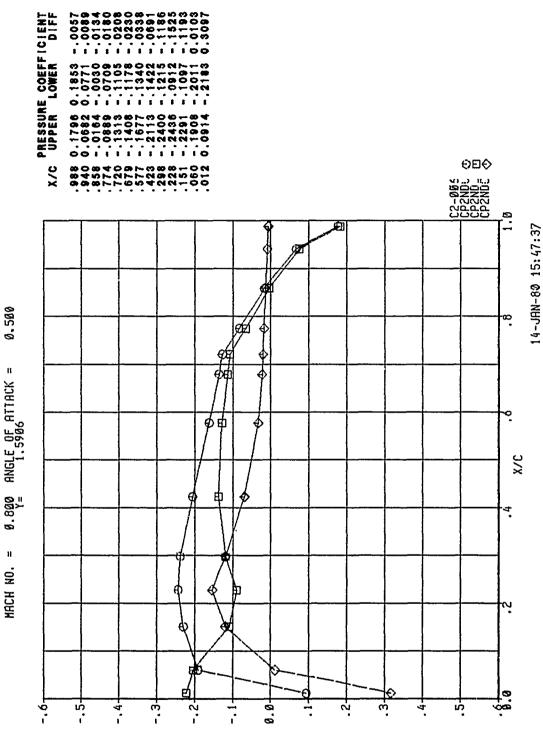


Figure 373, Chordwise Pressure Distribution, Steady, Configuration

 $C_{\mathbf{p}}$, pressure coefficient

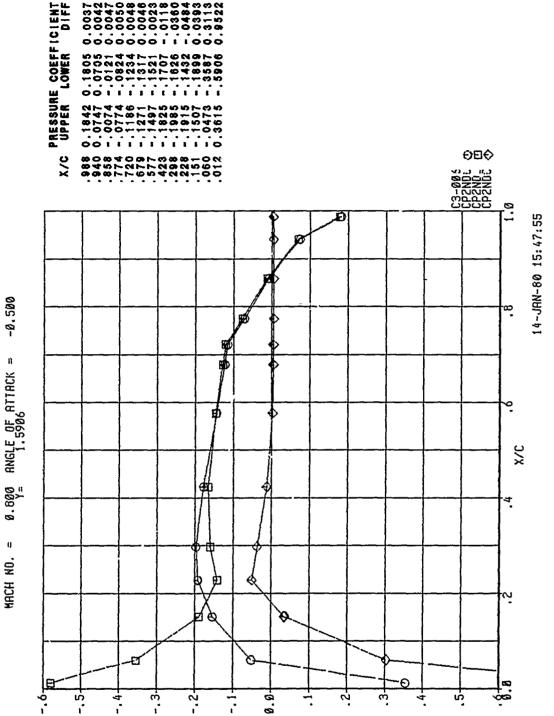


Figure 374, Chordwise Pressure Distribution, Steady, Configuration

 $C_{\mathbf{p}}$, pressure coefficient

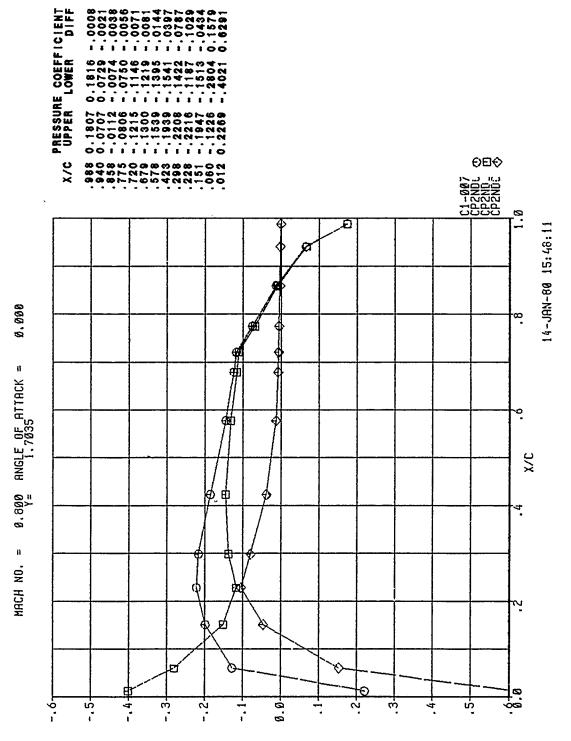


Figure 375, Chordwise Pressure Distribution, Steady, Configuration

 $\textbf{C}_{\textbf{p}}$ pressure coefficient

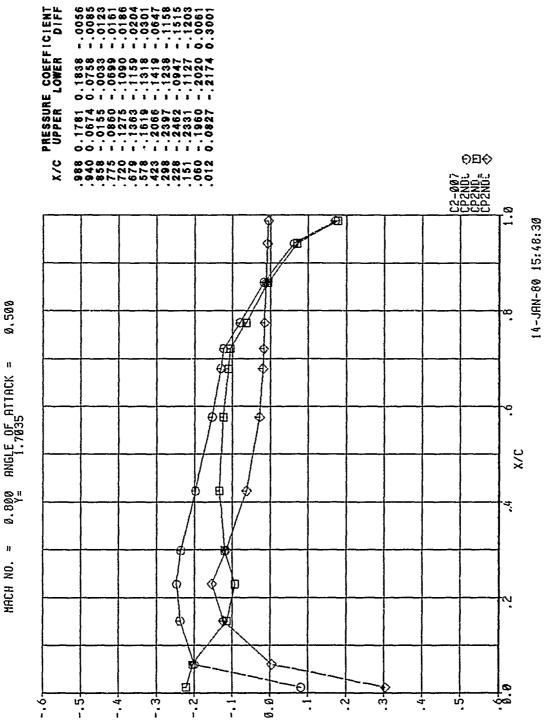
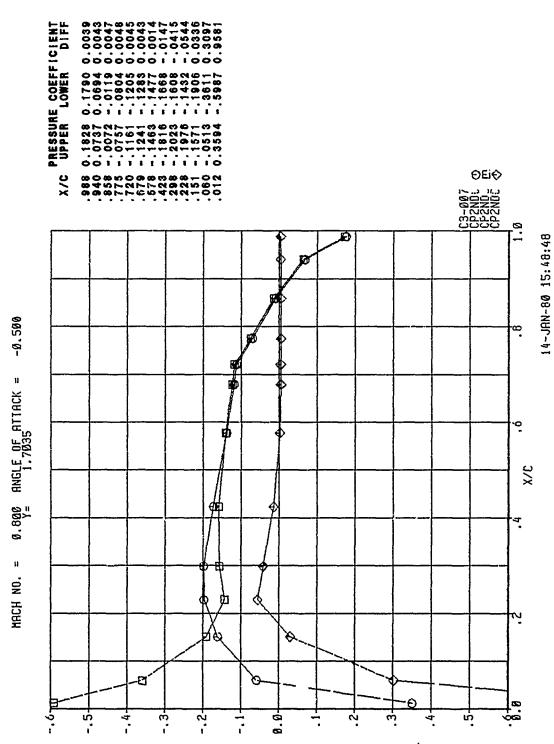


Figure 376, Chordwise Pressure Distribution, Steady, Configuration

C_p, pressure coefficient



377, Chordwise Pressure Distribution, Steady, Configuration

Figure

C_p, pressure coefficient

Figure 378, Chordwise Pressure Distribution, Steady, Configuration

 $C_{\mathbf{p}}$, pressure coefficient

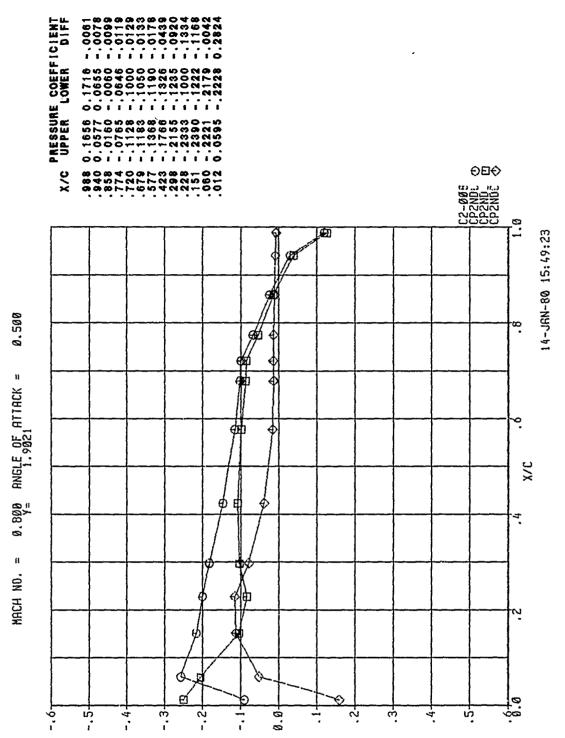


Figure 379, Chordwise Pressure Distribution, Steady, Configuration

 c_{p} , pressure coefficient

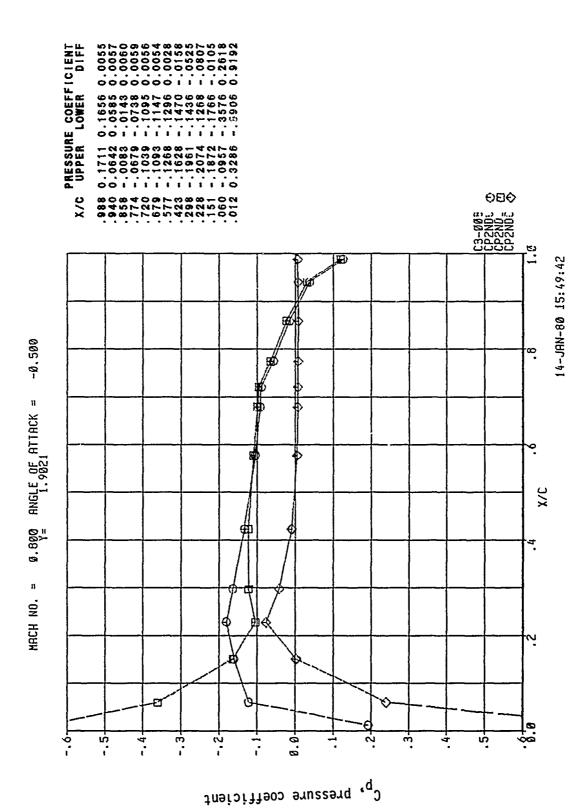


Figure 380, Chordwise Pressure Distribution, Steady, Configuration 3

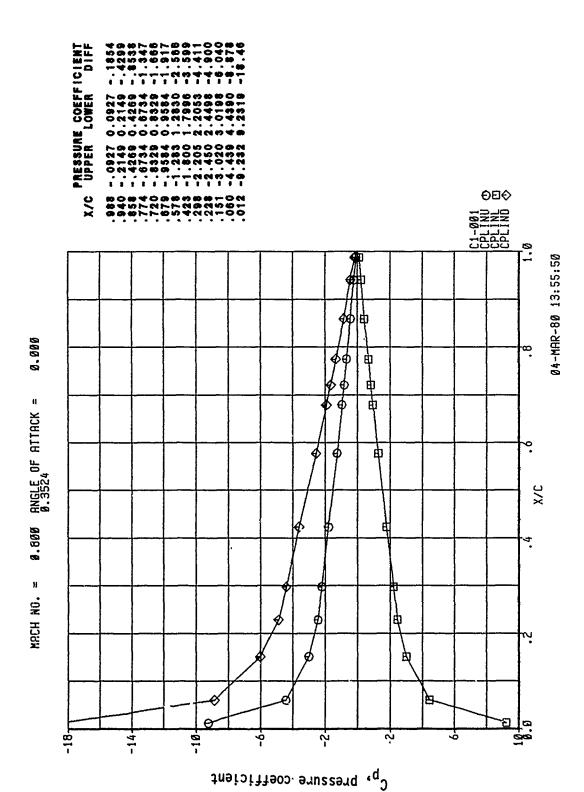


Figure 381, Chordwise Pressure Distribution, Real, Configuration 3

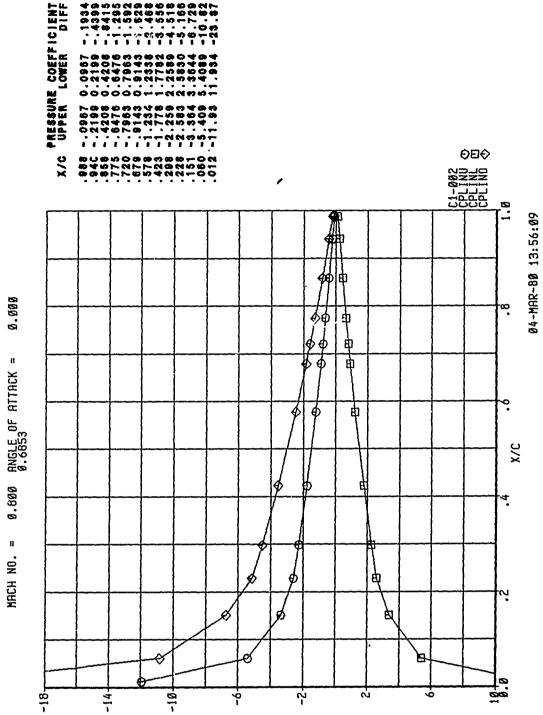


Figure 382, Chordwise Pressure Distribution, Real, Configuration

C_p, pressure coefficient

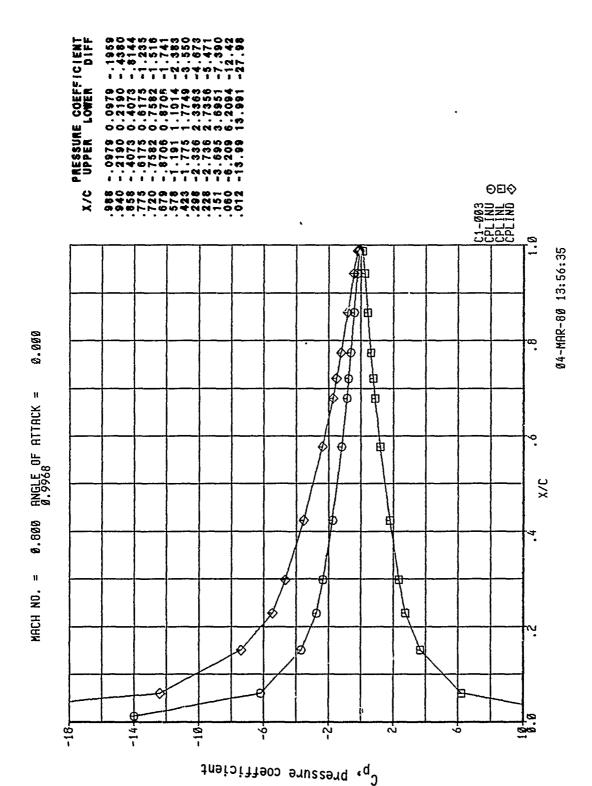


Figure 383, Chordwise Pressure Distribution, Real, Configuration

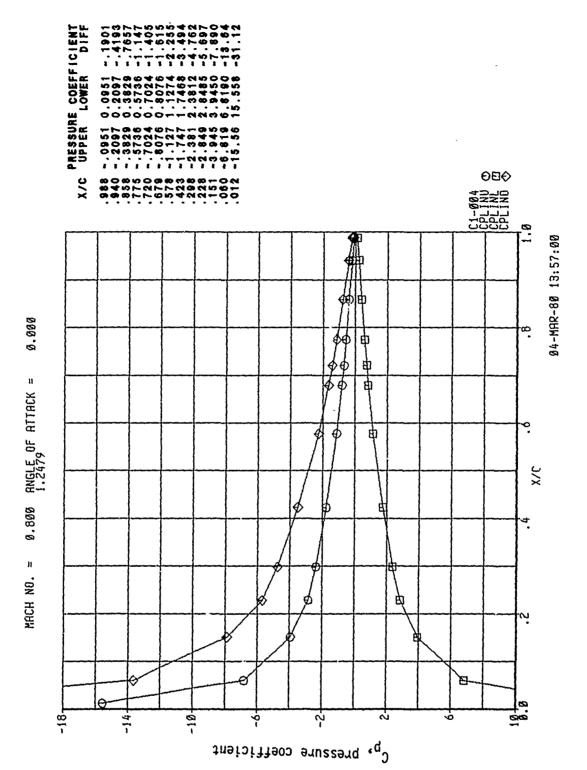


Figure 384, Chordwise Pressure Distribution, Real, Configuration

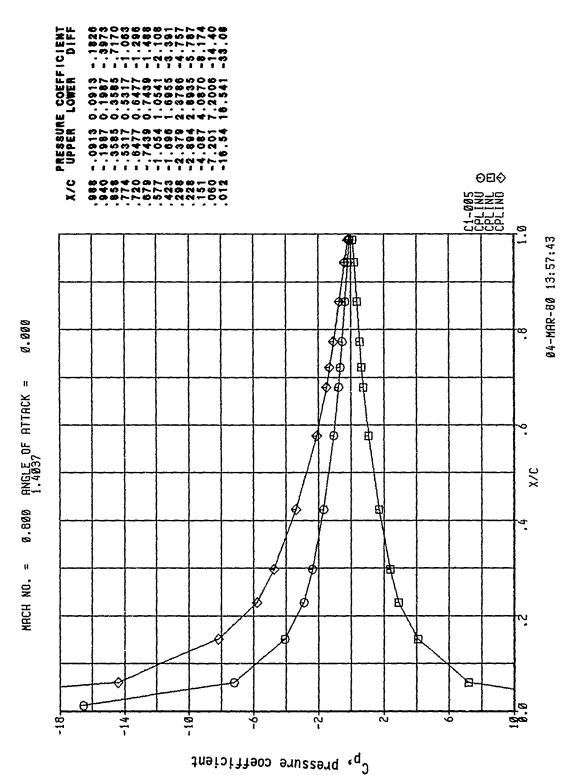


Figure 385, Chordwise Pressure Distribution, Real, Configuration

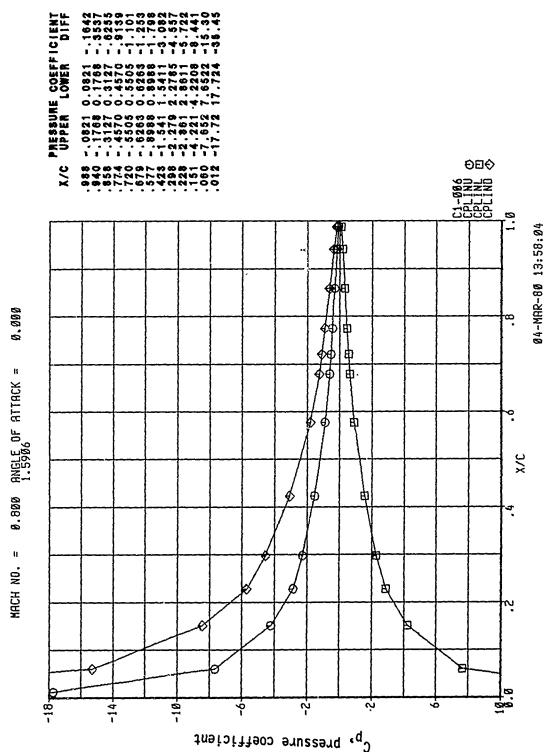
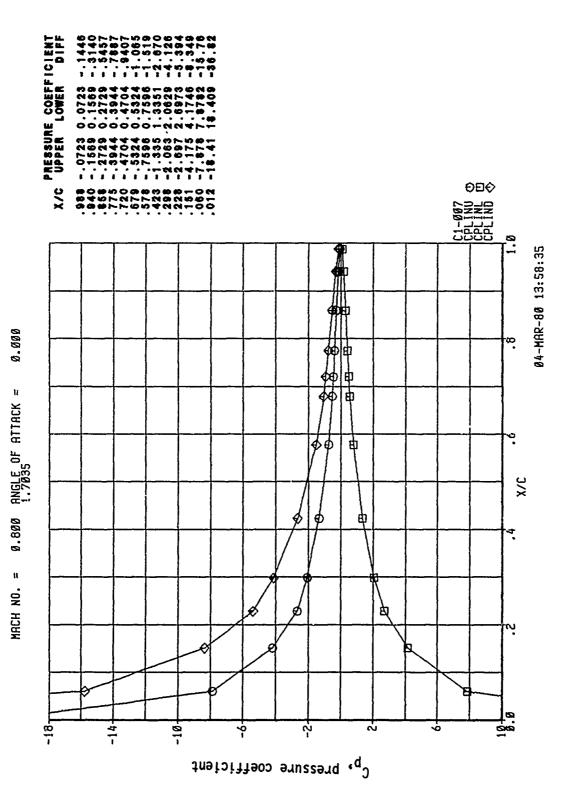


Figure 386, Chordwise Pressure Distribution, Real, Configuration 3



387, Chordwise Pressure Distribution, Real, Configuration Figure

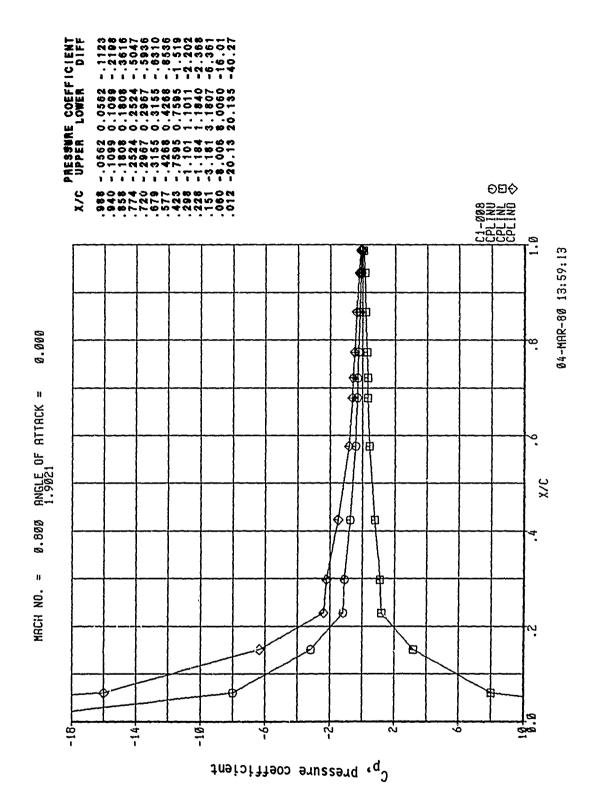


Figure 388, Chordwise Pressure Distribution, Real, Configuration 3

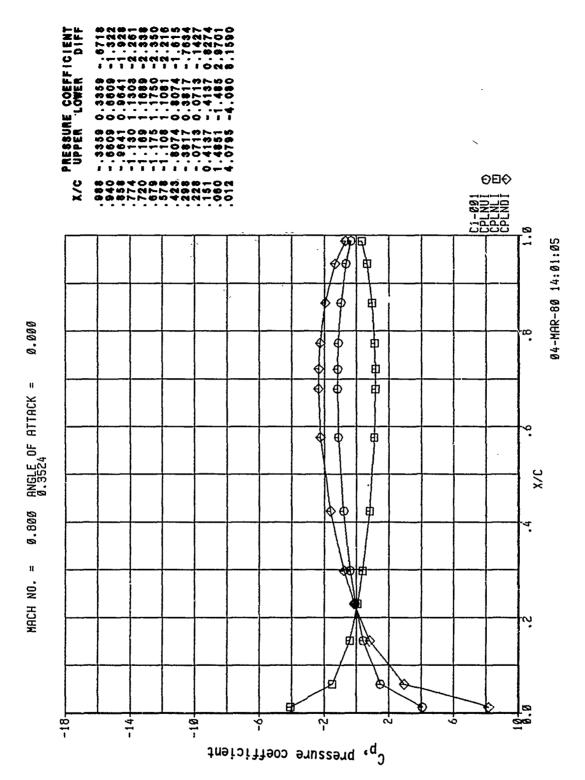


Figure 389, Chordwise Pressure Distribution, Imaginary, Configuration 3

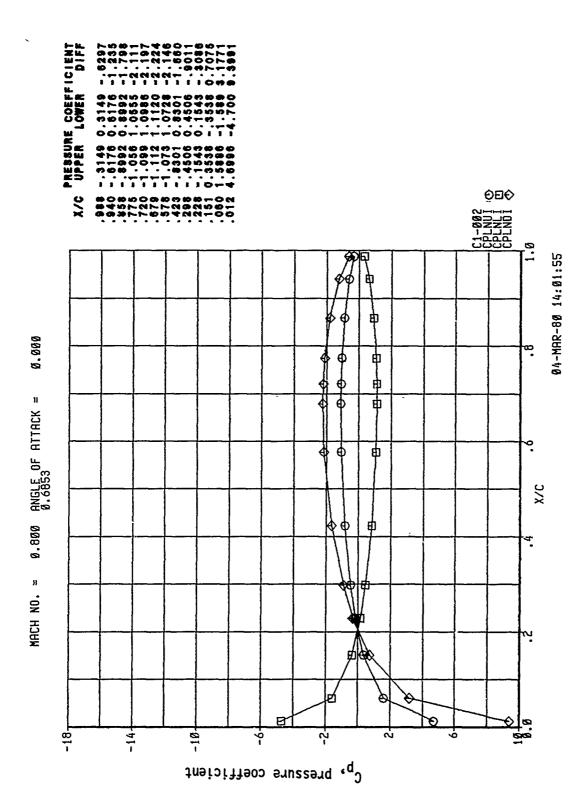


Figure 390, Chordwise Pressure Distribution, Imaginary, Configuration 3

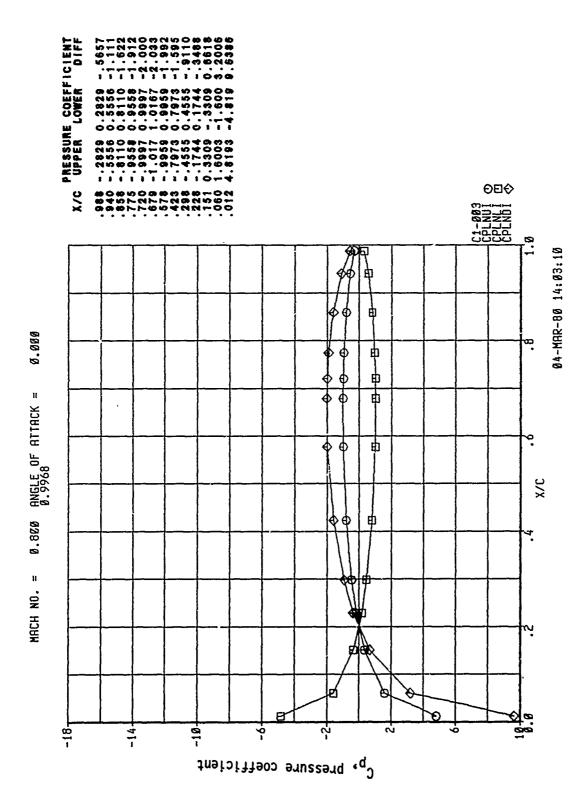


Figure 391, Chordwise Pressure Distribution, Imaginary, Configuration

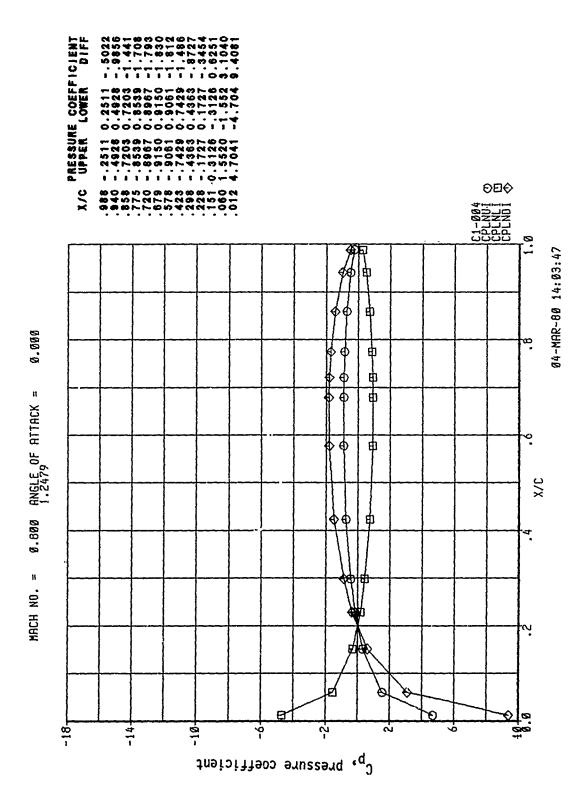


Figure 392, Chordwise Pressure Distribution, Imaginary, Configuration 3

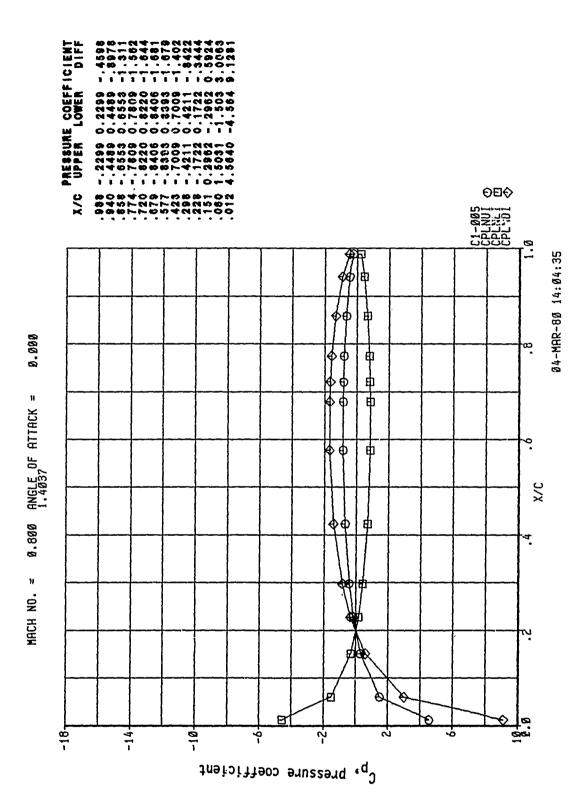


Figure 393, Chordwise Pressure Distribution, Imaginary, Configuration 3

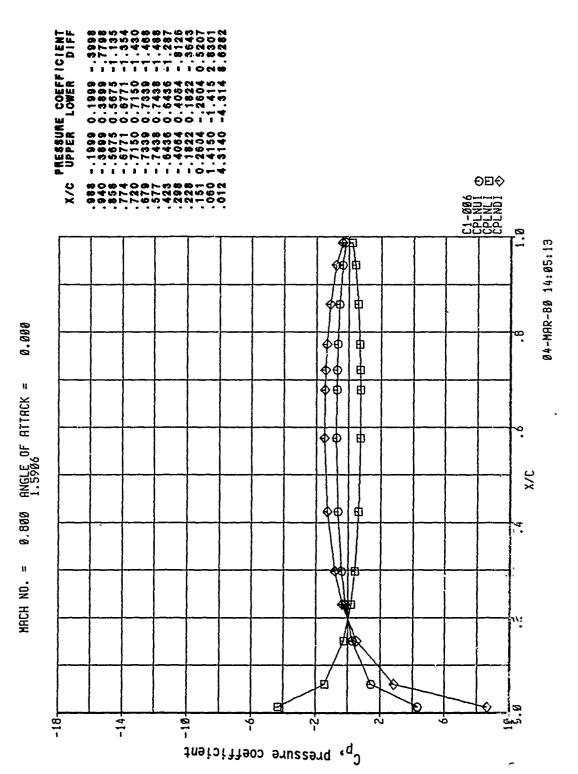


Figure 394, Chordwise Pressure Distribution, Imaginary, Configuration

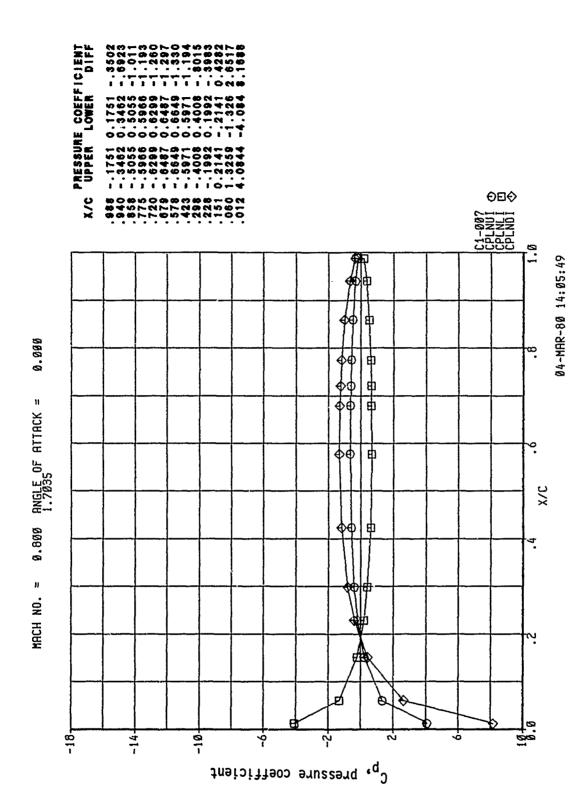


Figure 395, Chordwise Pressure Distribution, Imaginary, Configuration 3

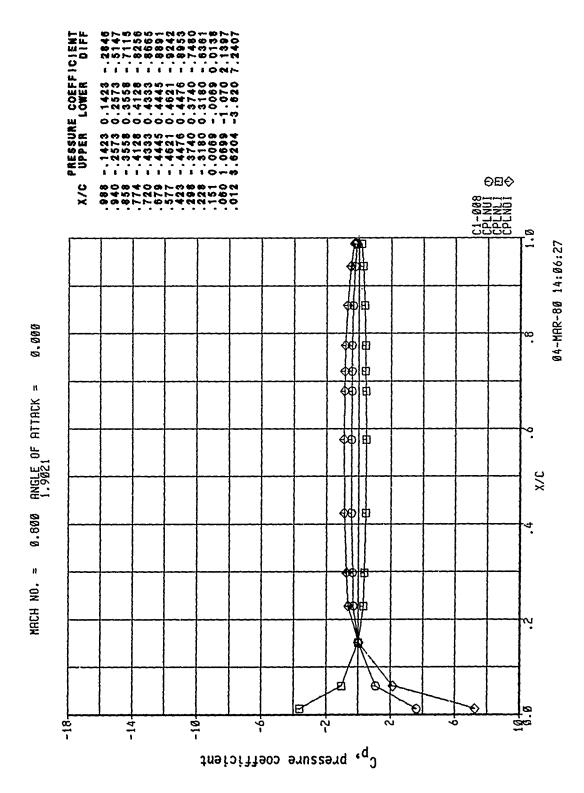
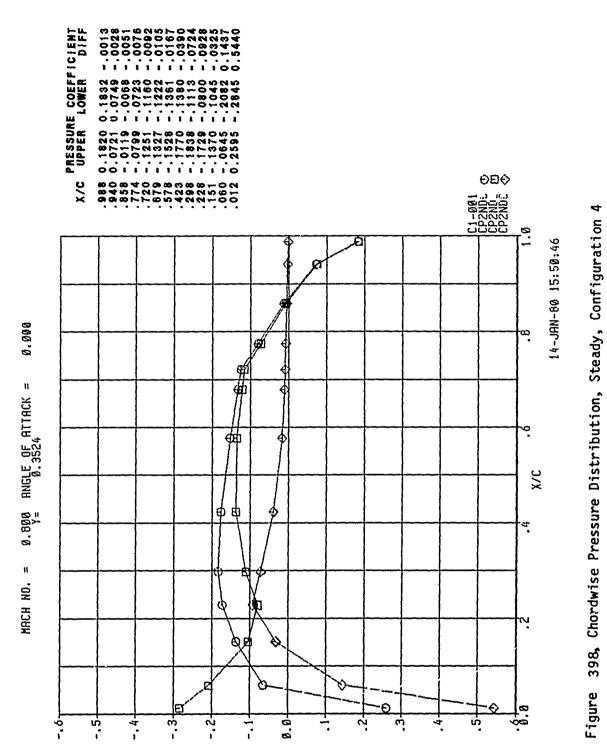


Figure 396, Chordwise Pressure Distribution, Imaginary, Configuration 3

Figure 397, Configuration 4



C_p, pressure coefficient

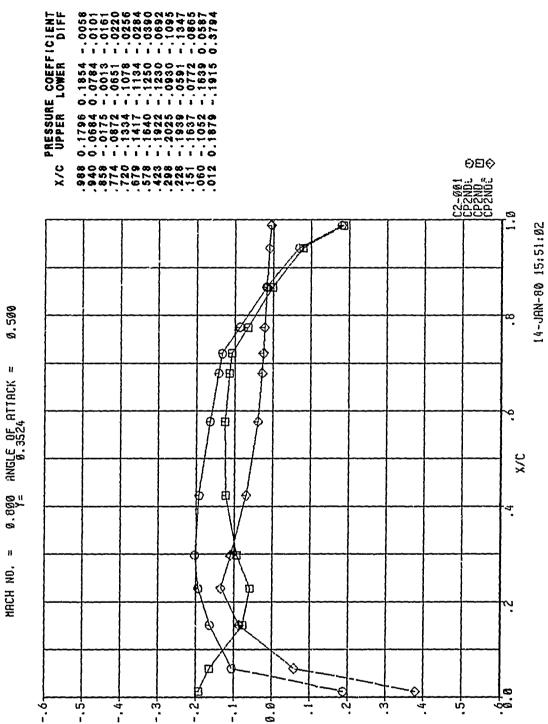


Figure 399, Chordwise Pressure Distribution, Steady, Configuration

theisitteos erusserd ${}_{
m q}$ J

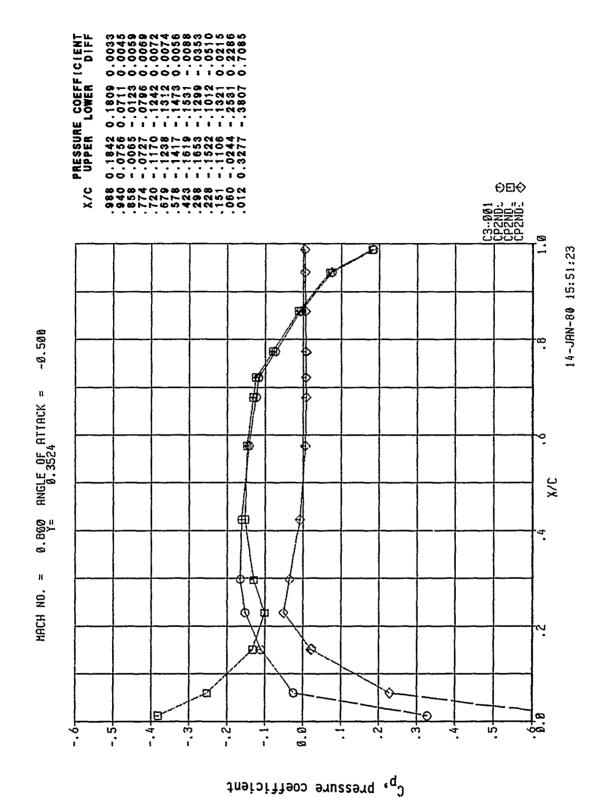


Figure 400, Chordwise Pressure Distribution, Steady, Configuration

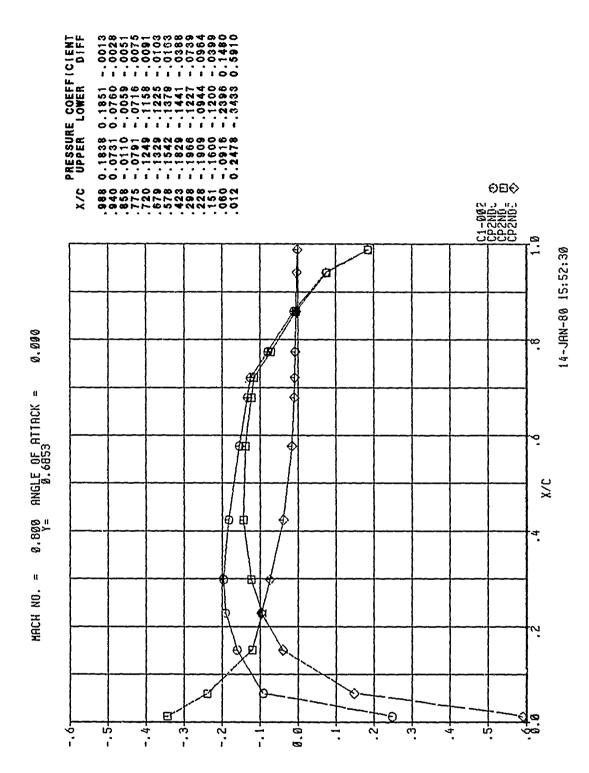


Figure 401, Chordwise Pressure Distribution, Steady, Configuration 4

 C_{p} , pressure coefficient

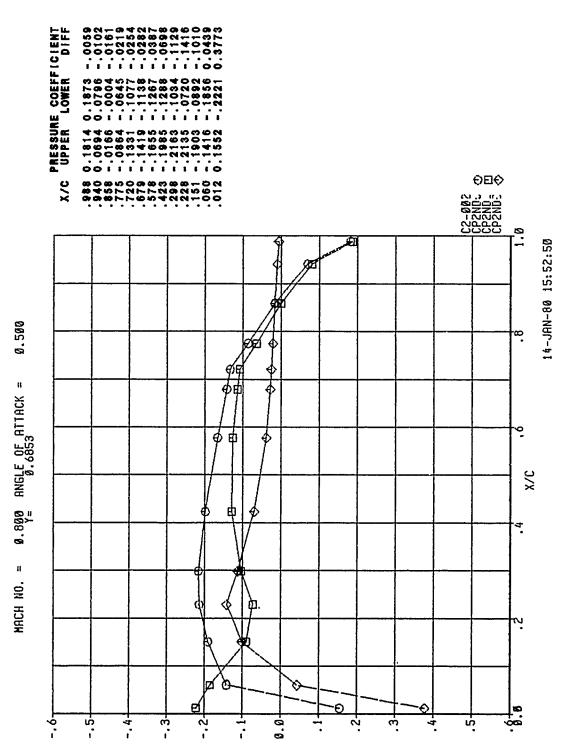


Figure 402, Chordwise Pressure Distribution, Steady, Configuration

 $\sigma_{\rm p}$, pressure coefficient

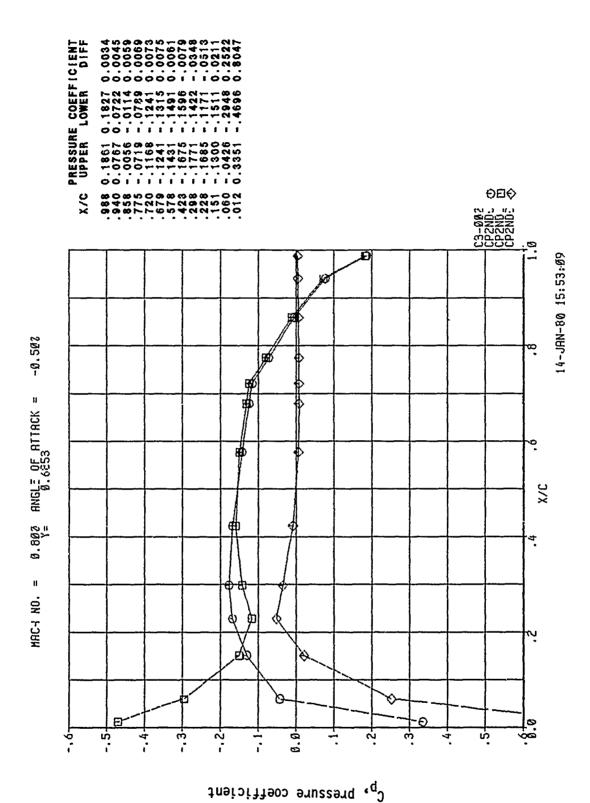


Figure 403, Chordwise Pressure Distribution, Steady, Configuration

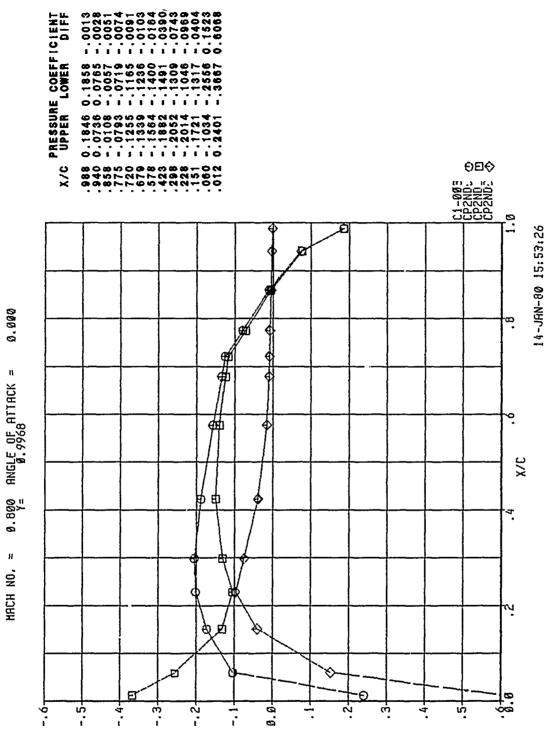


Figure 404, Chordwise Pressure Distribution, Steady, Configuration 4

C_p, pressure coefficient

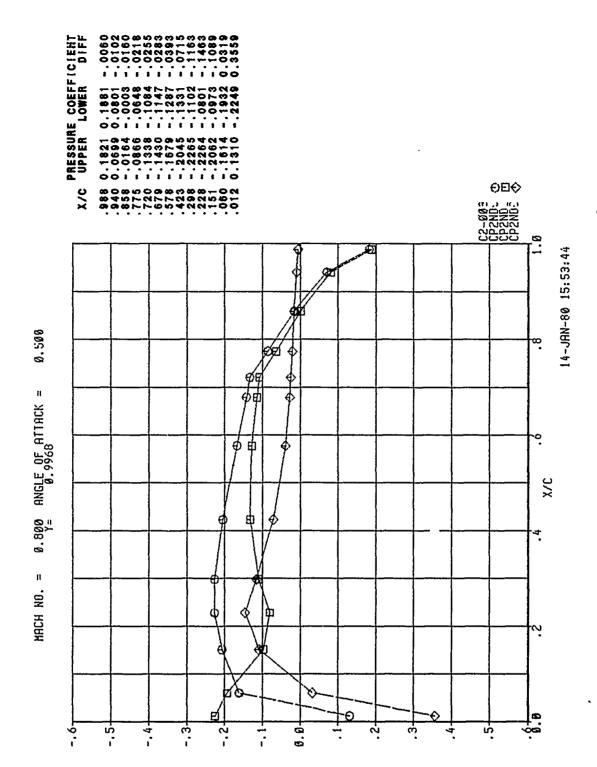


Figure 405, Chordwise Pressure Distribution, Steady, Configuration

 $c_{\mathbf{p}}$, pressure coefficient

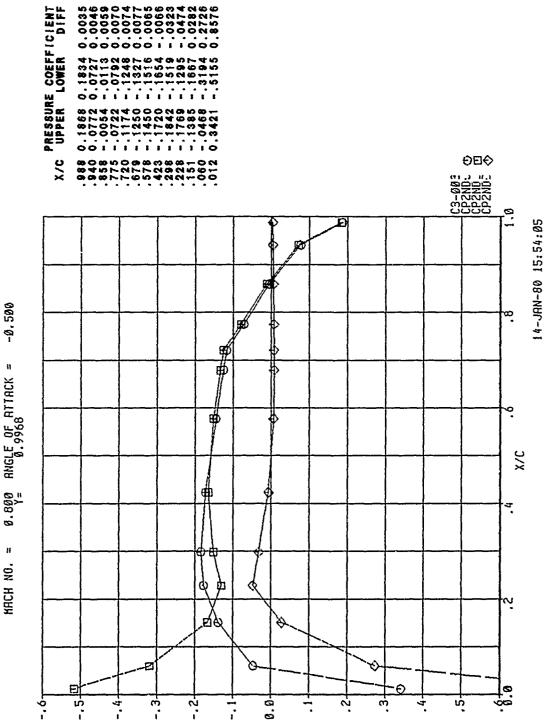


Figure 406, Chordwise Pressure Distribution, Steady, Configuration

 $C_{\mathbf{p}}$, pressure coefficient

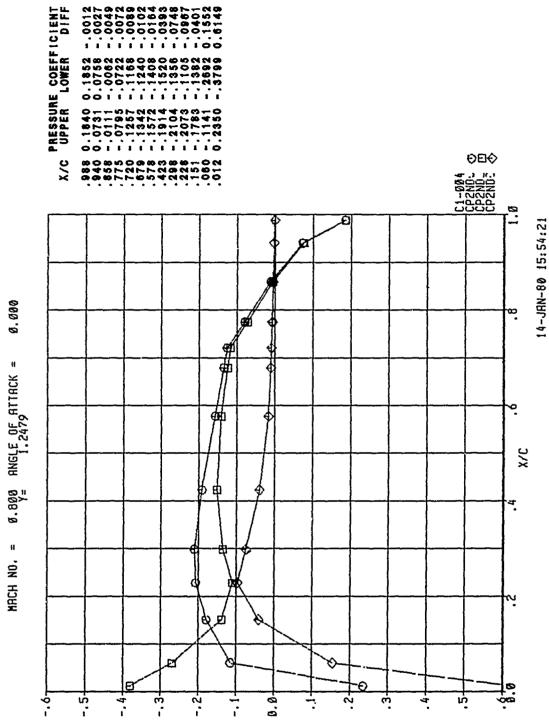


Figure 407, Chordwise Pressure Distribution, Steady, Configuration

fressure coefficient $q^{\mathcal{O}}$

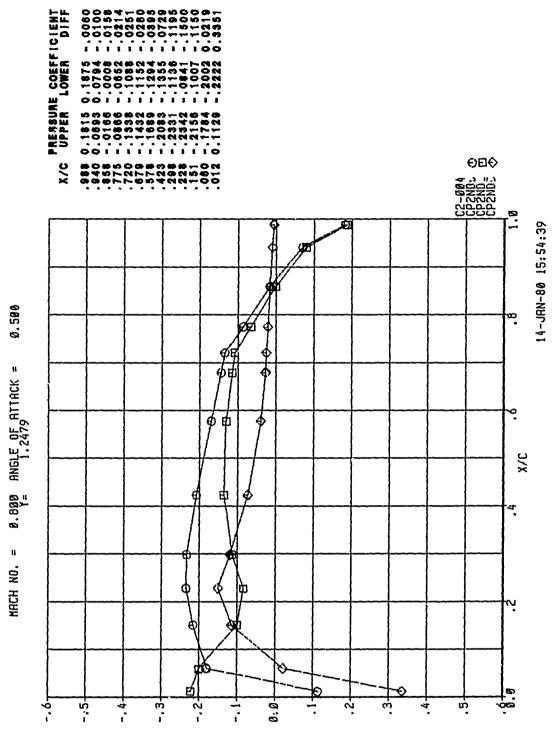


Figure 408, Chordwise Pressure Distribution, Steady, Configuration

 $c_{
m p}$, pressure coefficient

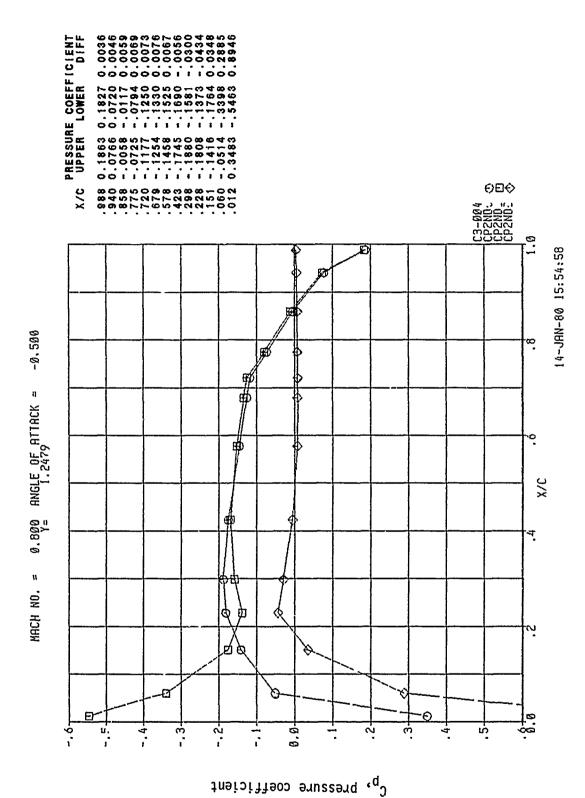


Figure 409, Chordwise Pressure Distribution, Steady, Configuration

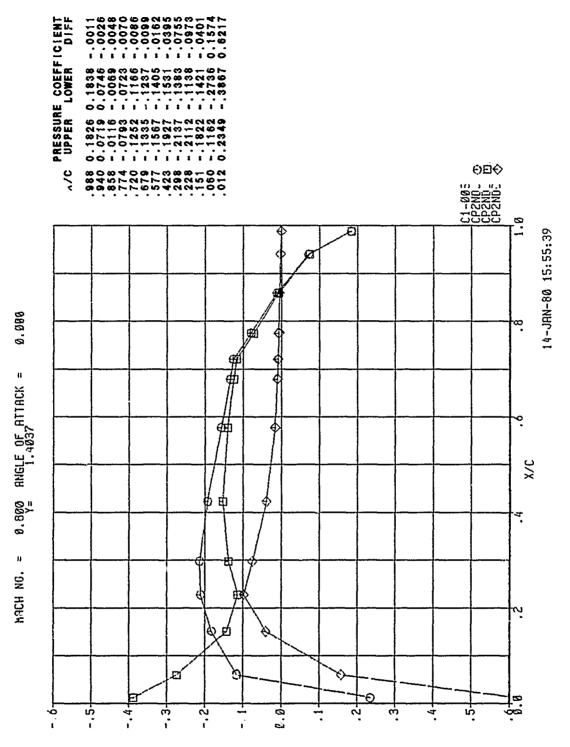


Figure 410, Chordwise Pressure Distribution, Steady, Configuration

Cn, pressure coefficient

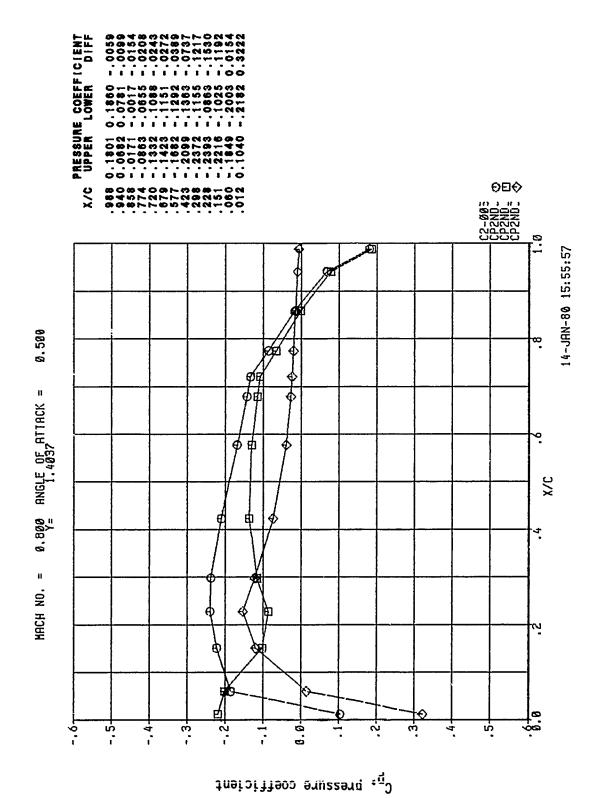


Figure 411, Chordwise Pressure Distribution, Steady, Configuration

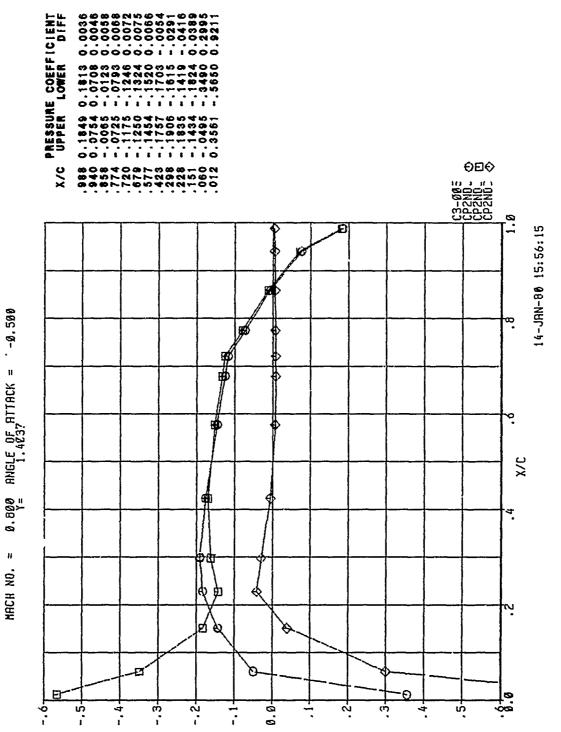


Figure 412, Chordwise Pressure Distribution, Steady, Configuration

Cp, pressure coefficient

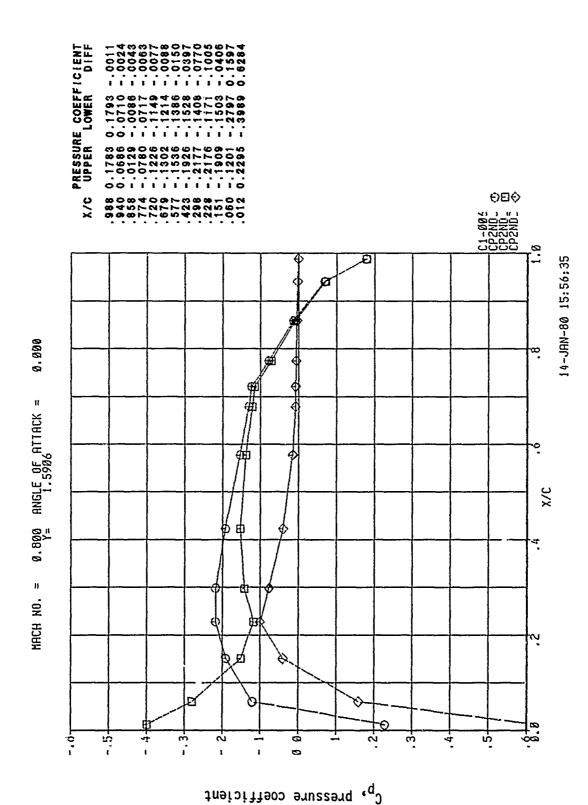


Figure 413, Chordwise Pressure Distribution, Steady, Configuration 4

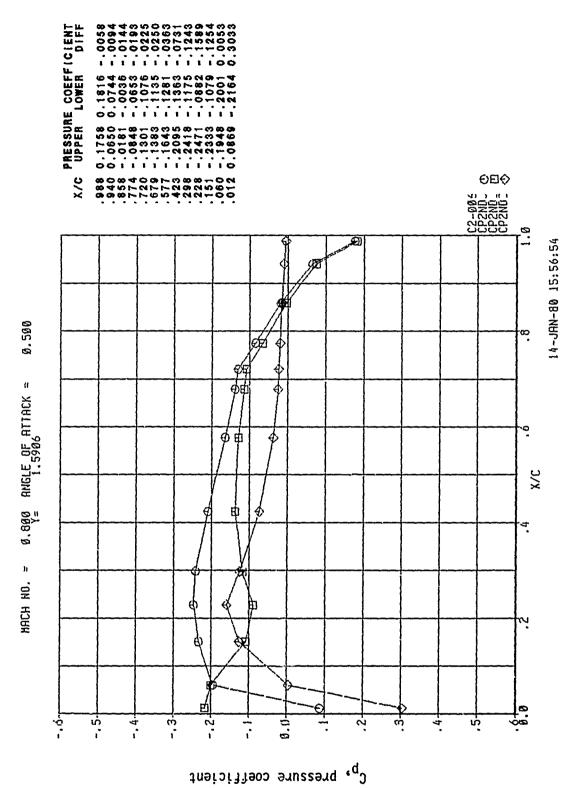


Figure 414, Chordwise Pressure Distribution, Steady, Configuration 4

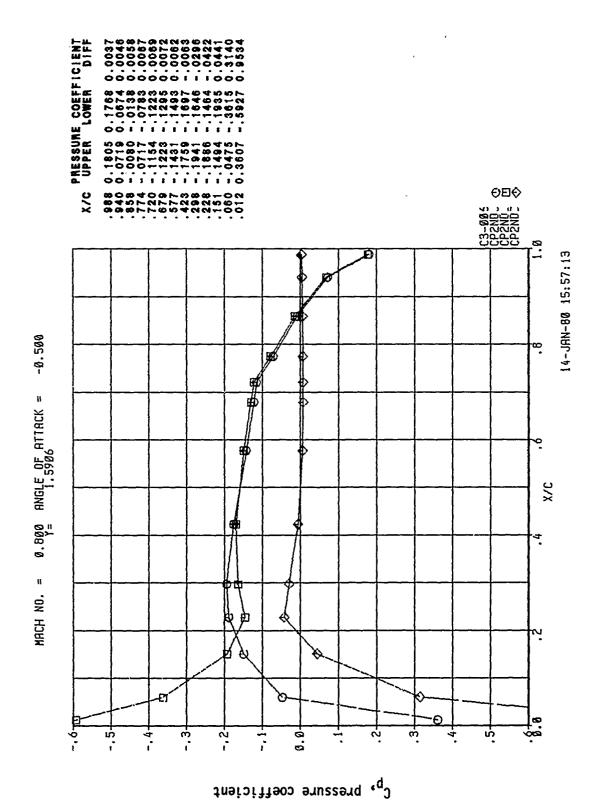
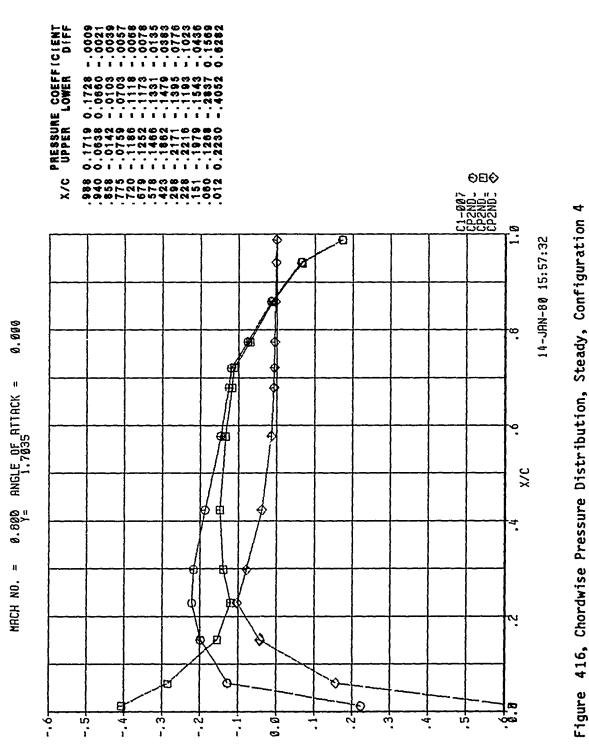


Figure 415, Chordwise Pressure Distribution, Steady, Configuration 4



C_p, pressure coefficient

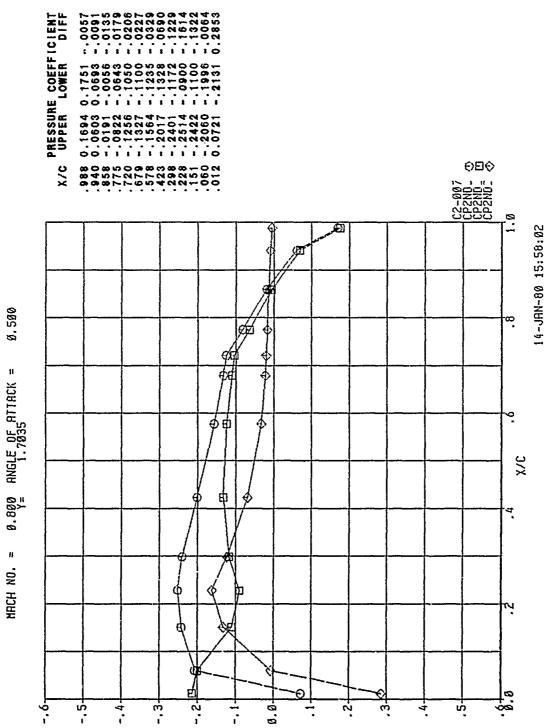


Figure 417, Chordwise Pressure Distribution, Steady, Configuration

 $\sigma_{\rm p}$ pressure coefficient

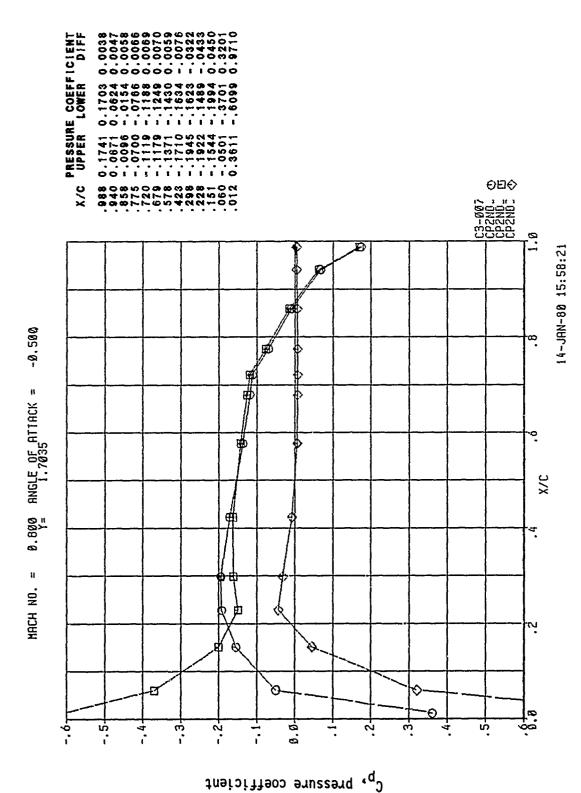


Figure 418, Chordwise Pressure Distribution, Steady, Configuration

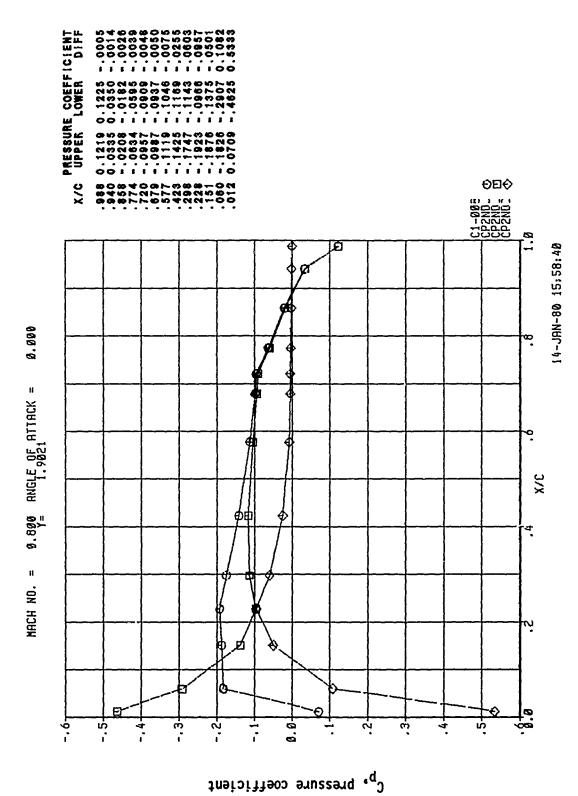


Figure 419, Chordwise Pressure Distribution, Steady, Configuration

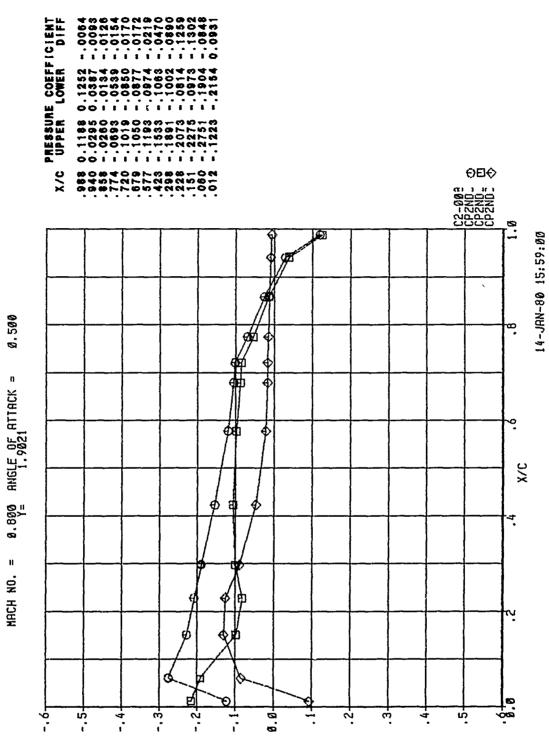


Figure 420, Chordwise Pressure Distribution, Steady, Configuration 4

1

C_p, pressure coefficient

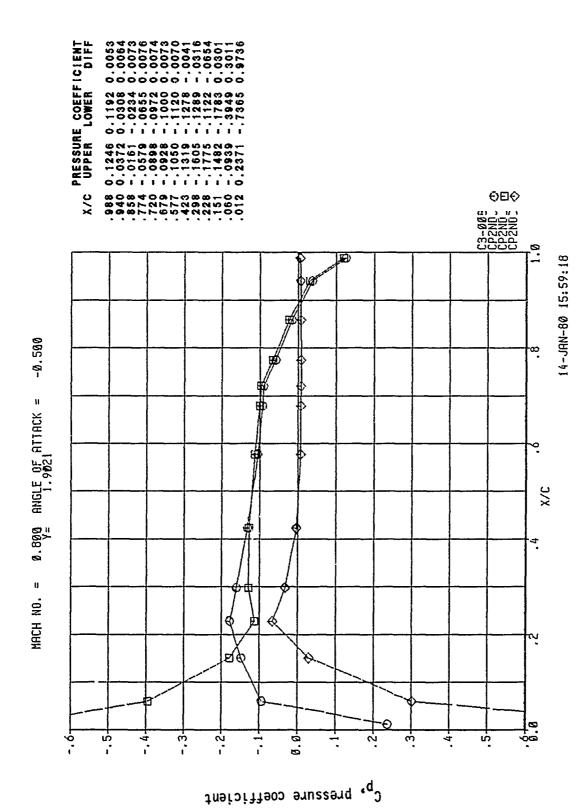


Figure 421, Chordwise Pressure Distribution, Steady, Configuration 4

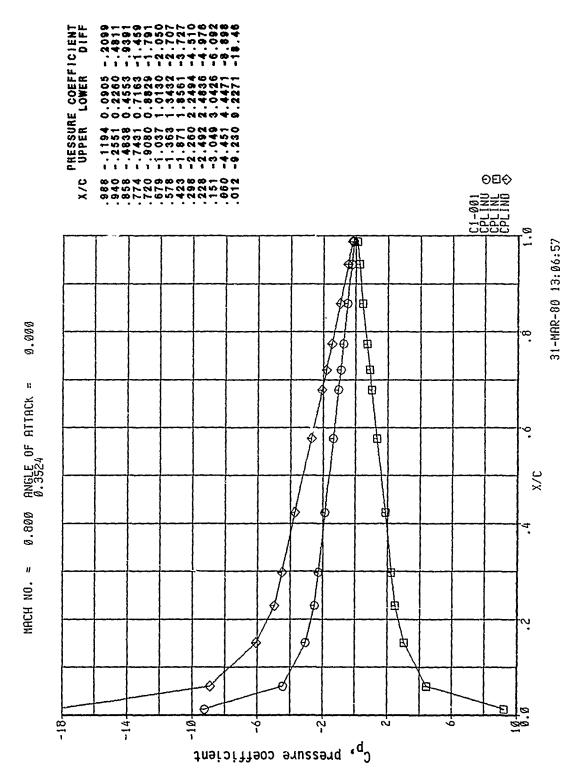


Figure 422, Chcrdwise Pressure Distribution, Real, Configuration 4

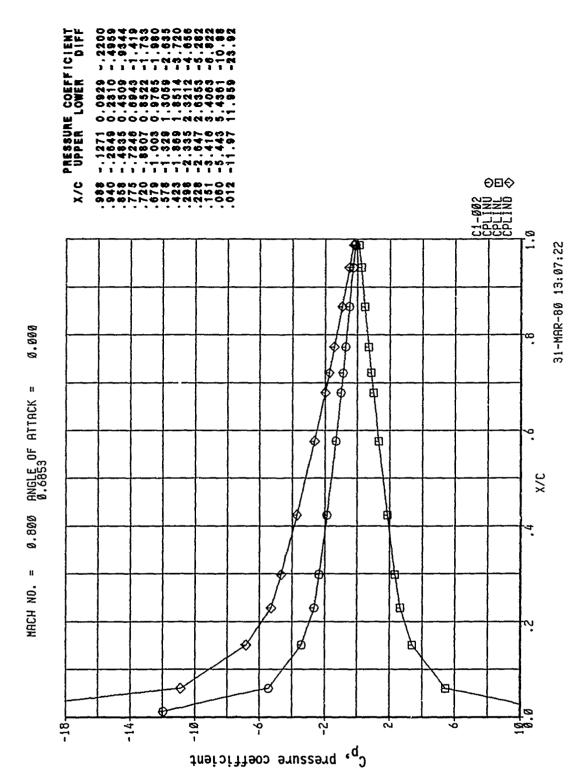


Figure 423, Chordwise Pressure Distribution, Real, Configuration 4

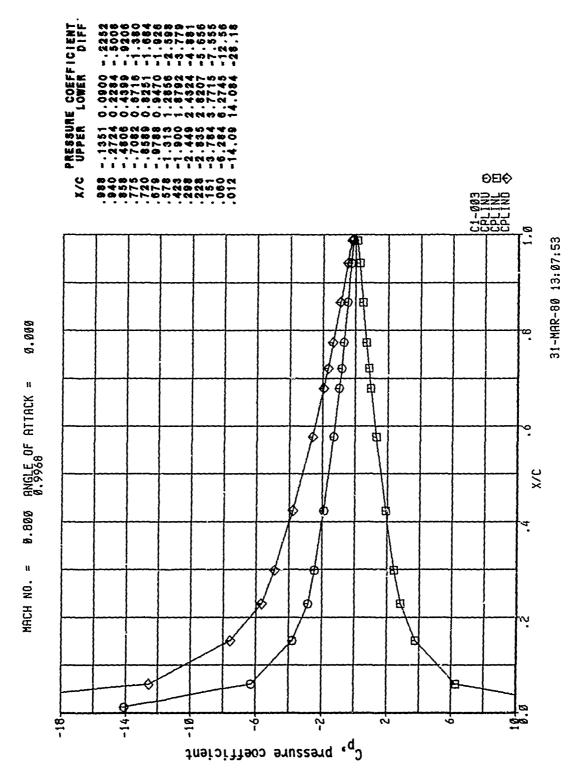


Figure 424, Chordwise Pressure Distribution, Real, Configuration 4

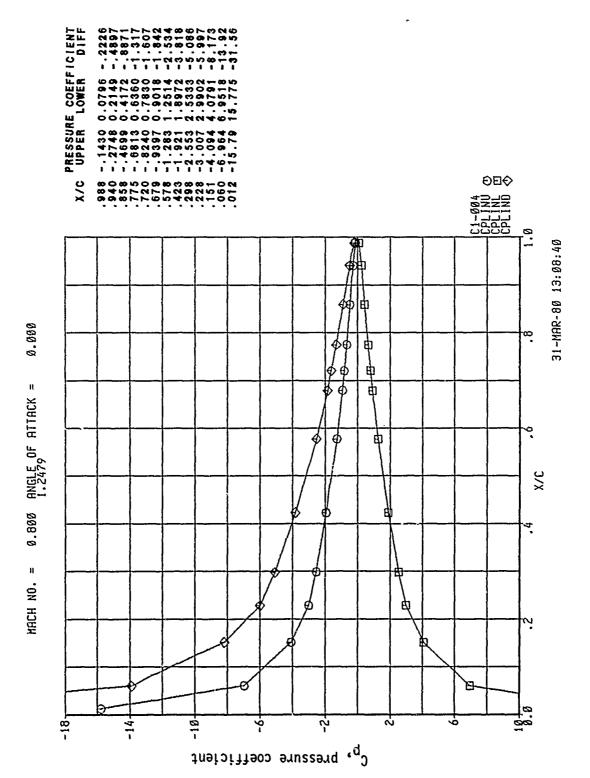


Figure 425, Chordwise Pressure Distribution, Real, Configuration 4

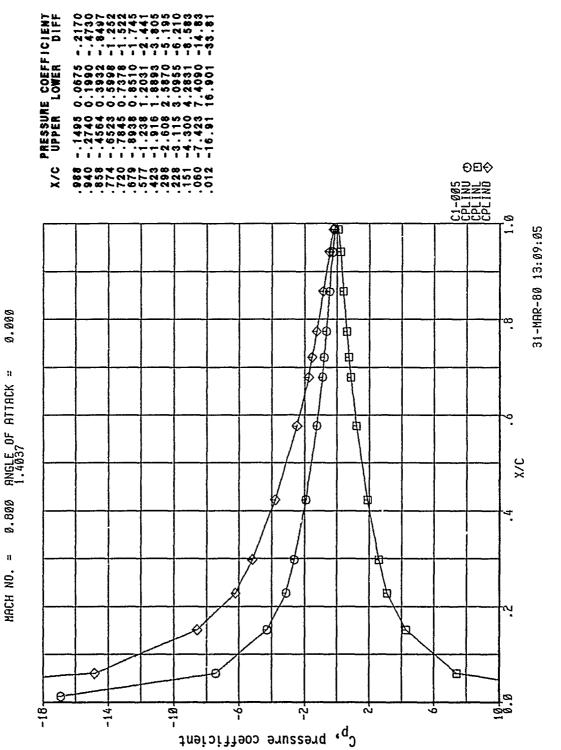


Figure 426, Chordwise Pressure Distribution, Real, Configuration 4

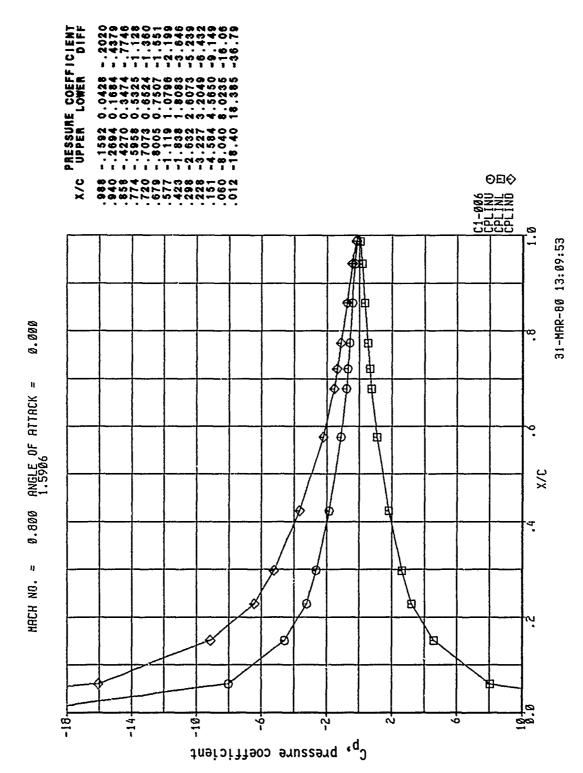


Figure 427, Chordwise Pressure Distribution, Real, Configuration 4

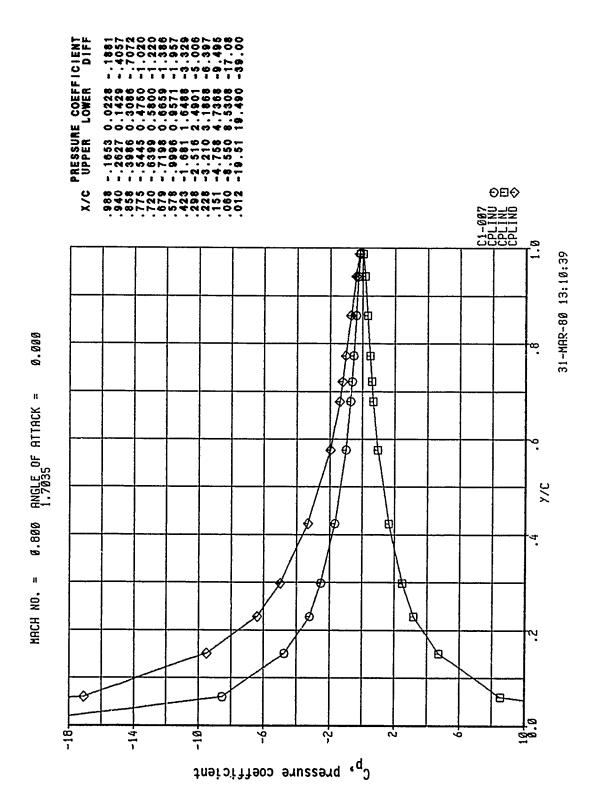


Figure 428, Chordwise Pressure Distribution, Real, Configuration 4

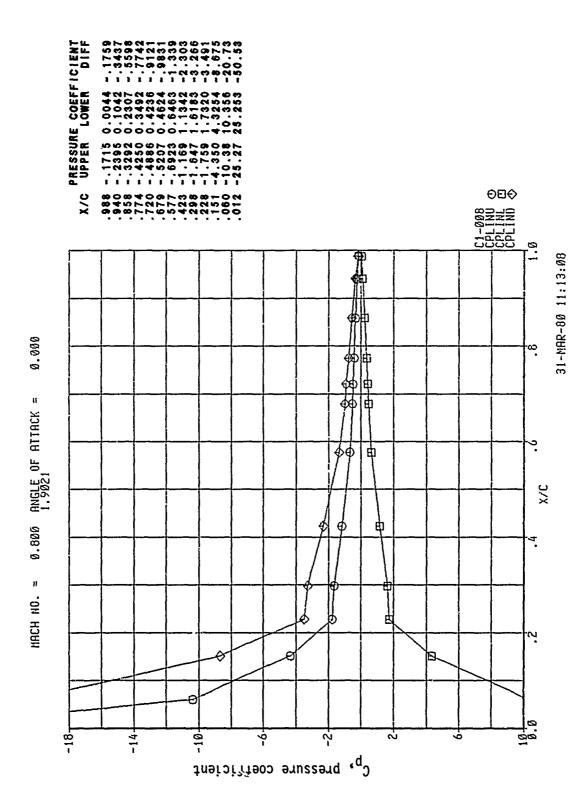


Figure 429, Chordwise Pressure Distribution, Real, Configuration 4

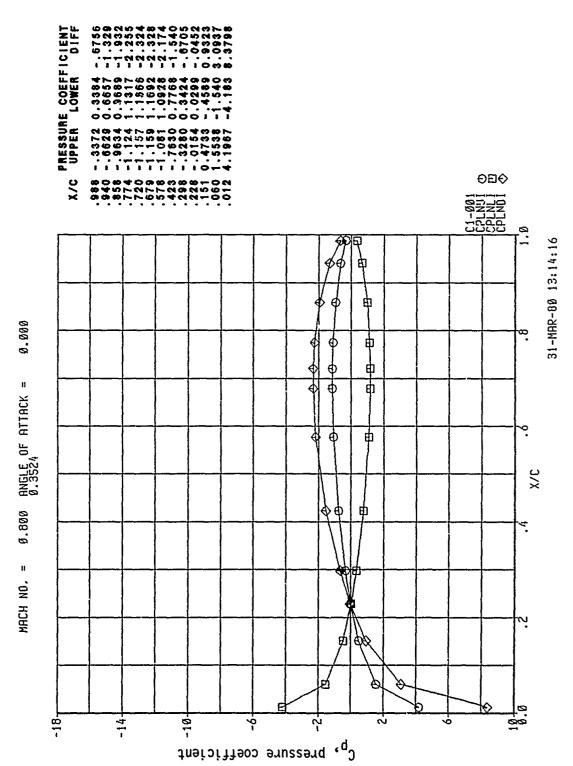


Figure 430, Chordwise Pressure Distribution, Imaginary, Configuration

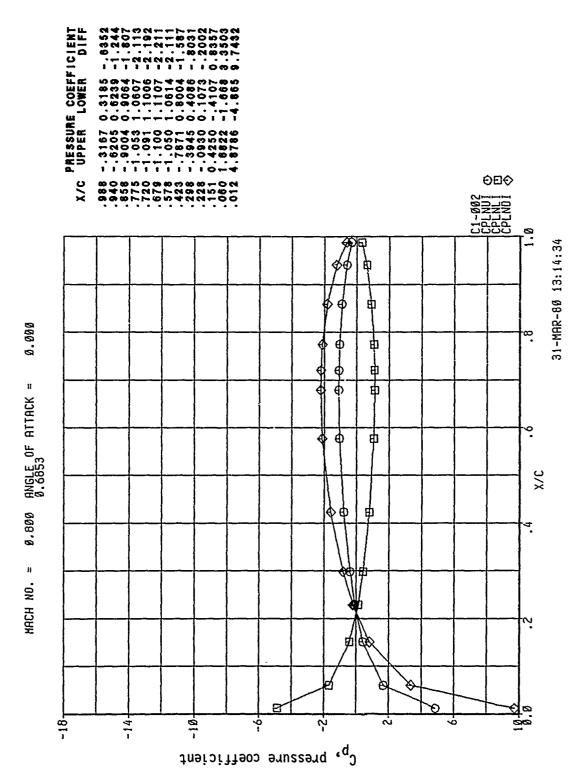


Figure 431, Chordwise Pressure Distribution, Imaginary, Configuration 4

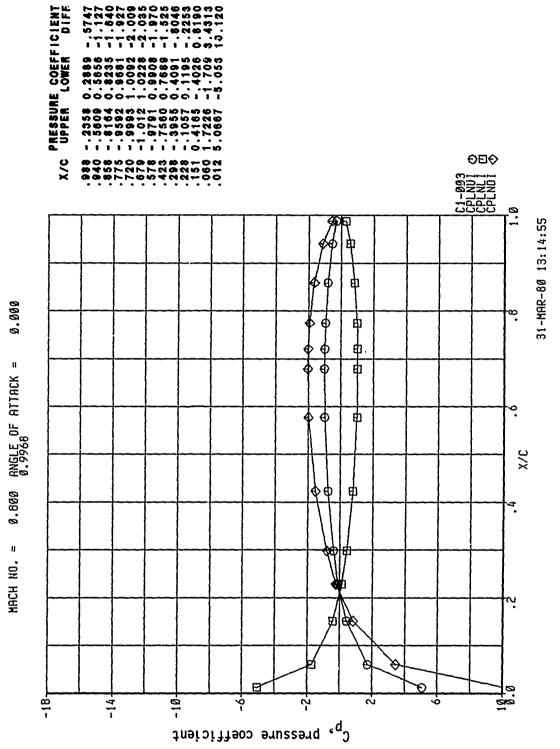


Figure 432, Chordwise Pressure Distribution, Imaginary, Configuration 4

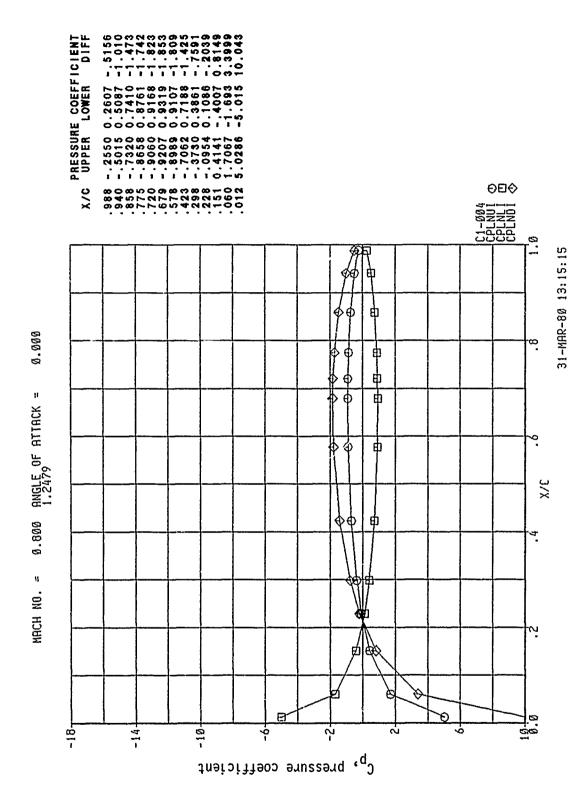


Figure 433, Chordwise Pressure Distribution, Imaginary, Configuration

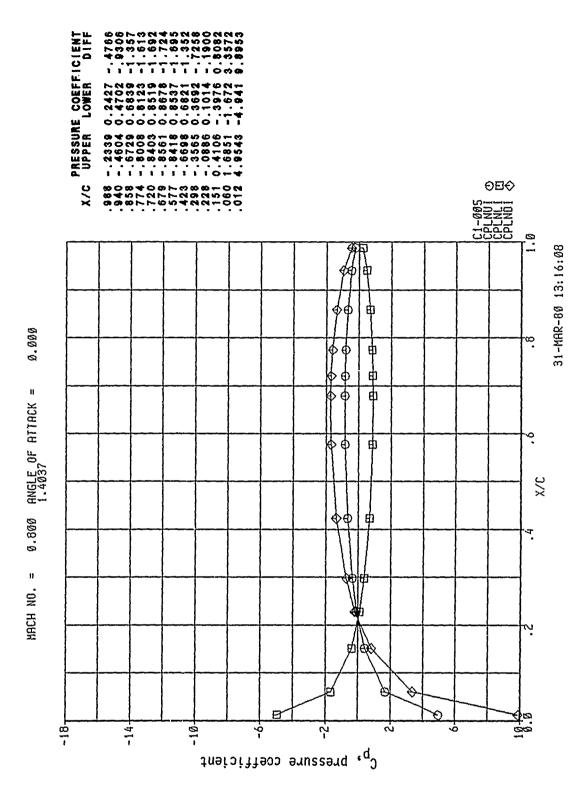
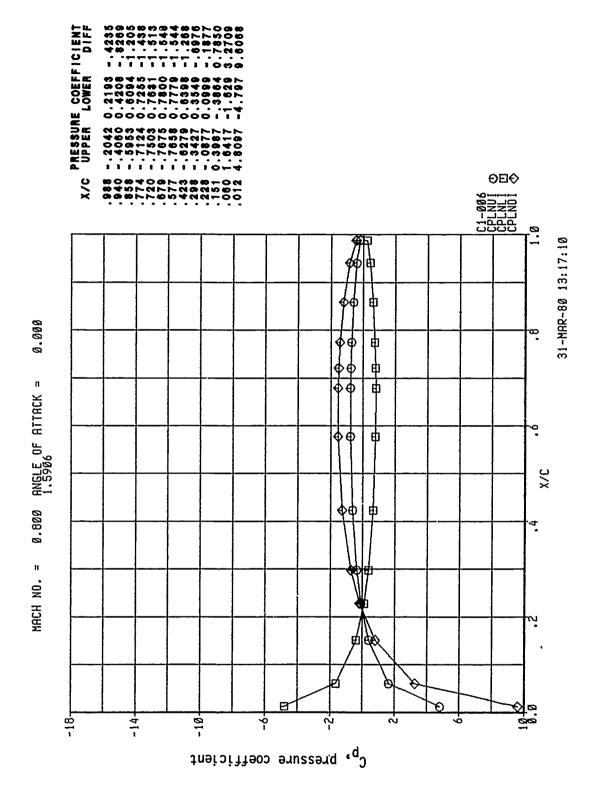


Figure 434, Chordwise Pressure Distribution, Imaginary, Configuration



435, Chordwise Pressure Distribution, Imaginary, Configuration Figure

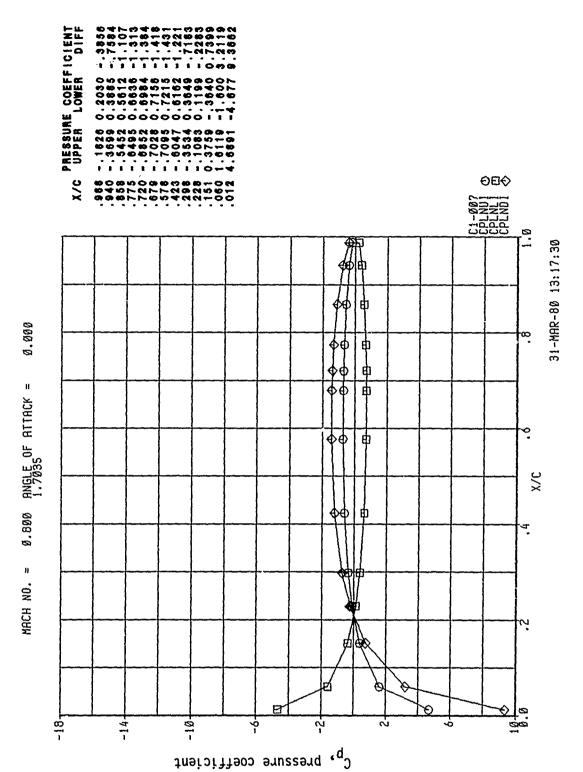


Figure 436, Chordwise Pressure Distribution, Imaginary, Configuration 4

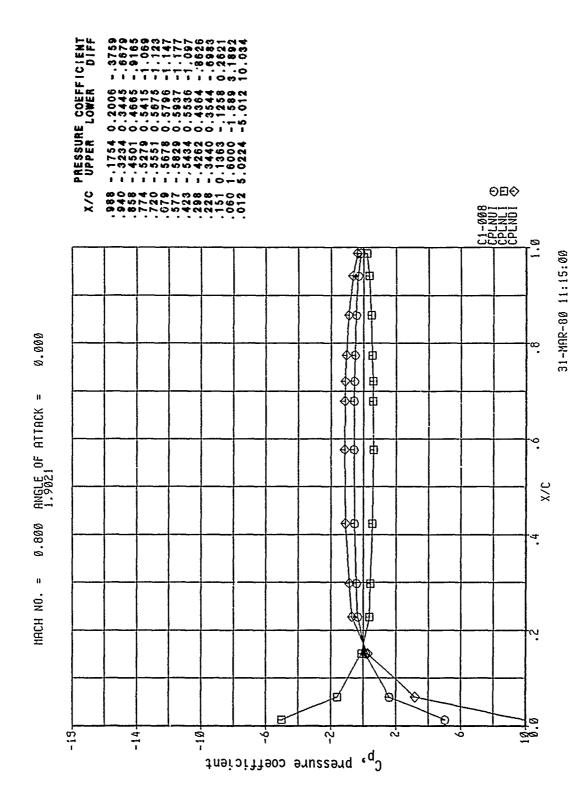
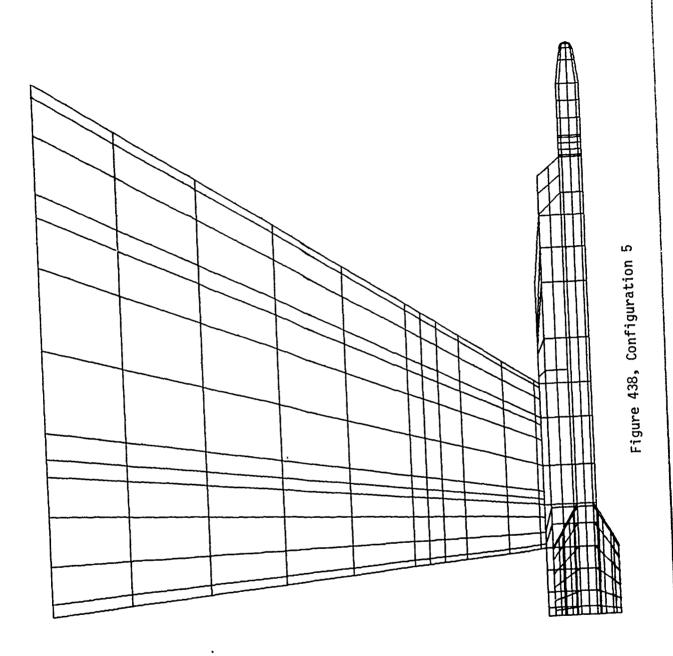


Figure 437, Chordwise Pressure Distribution, Imaginary, Configuration 4



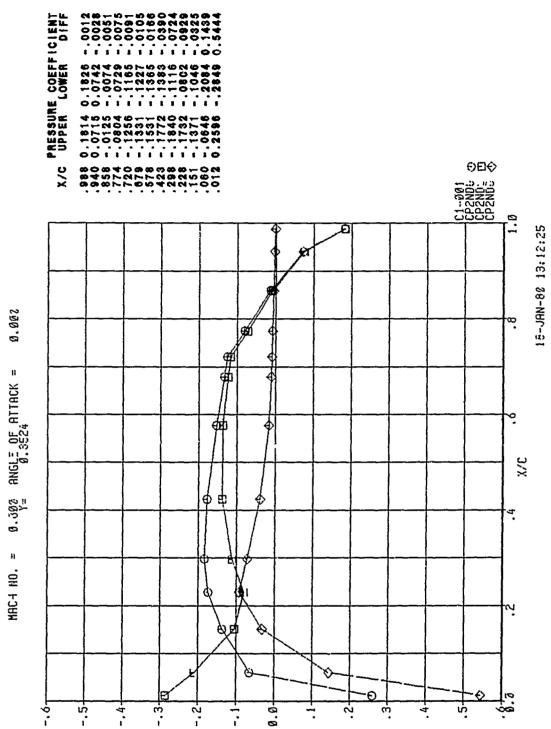


Figure 439, Chordwise Pressure Distribution, Steady, Configuration

C_p, pressure coefficient

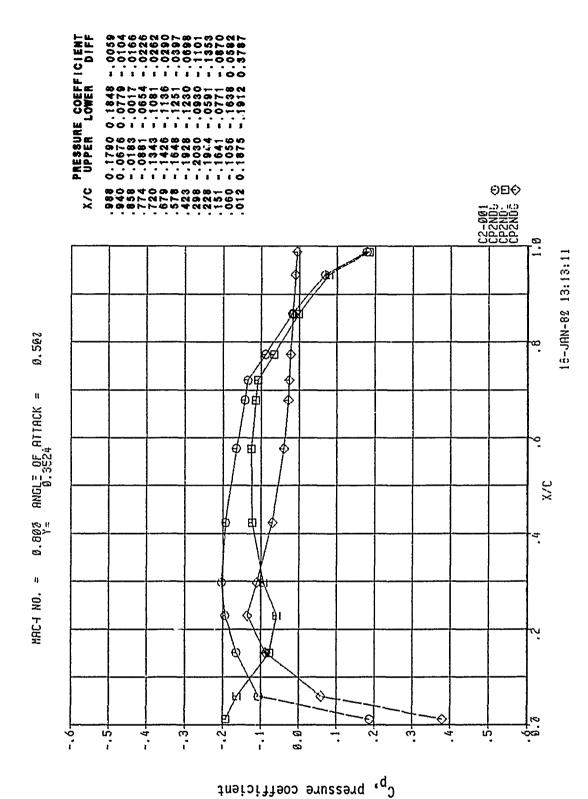
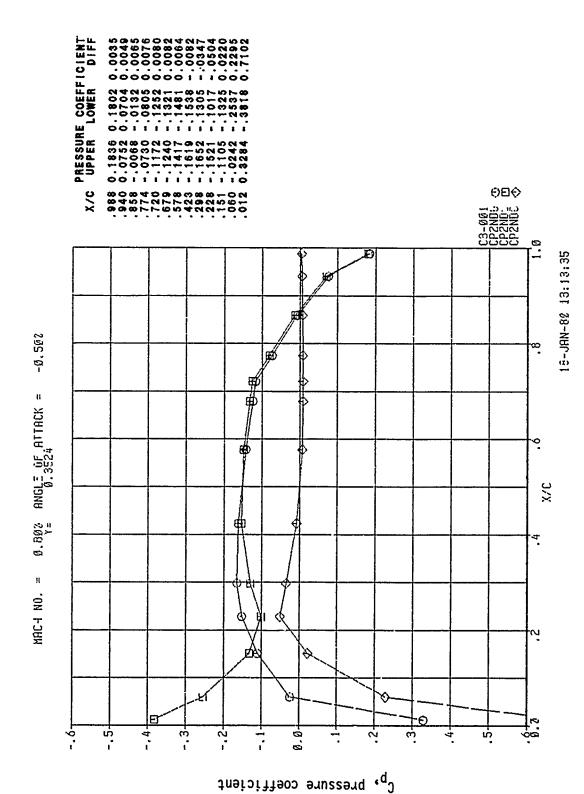


Figure 440, Chordwise Pressure Distribution, Steady, Configuration



Ŋ Figure 441, Chordwise Pressure Distribution, Steady, Configuration

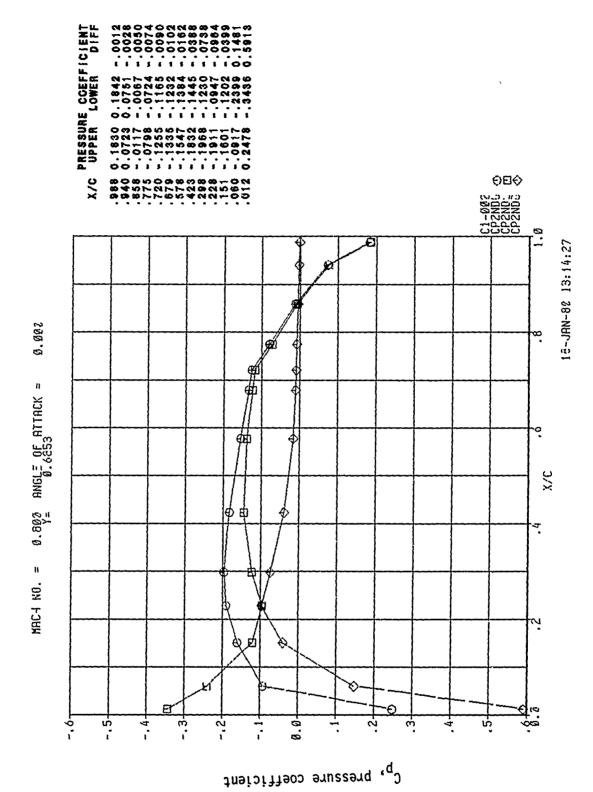
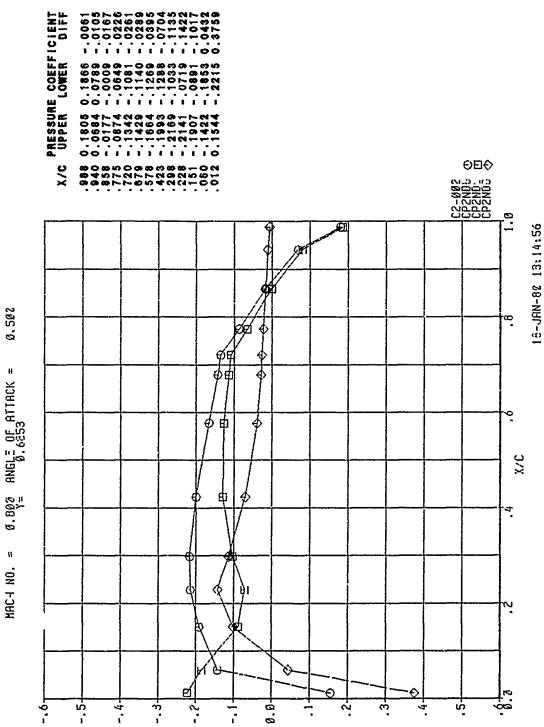


Figure 442, Chordwise Pressure Distribution, Steady, Configuration

ည



ស

Figure 443, Chordwise Pressure Distribution, Steady, Configuration

Jpressure coefficient

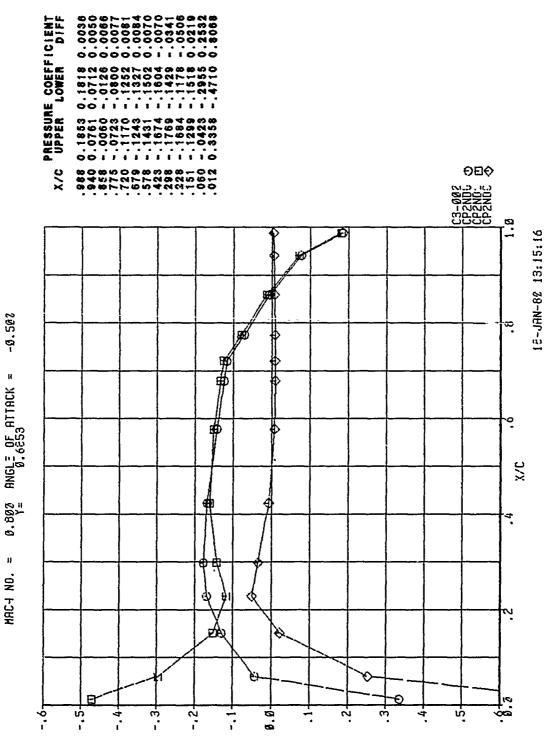


Figure 444, Chordwise Pressure Distribution, Steady, Configuration 5

 $c_{
m p}$, pressure coefficient

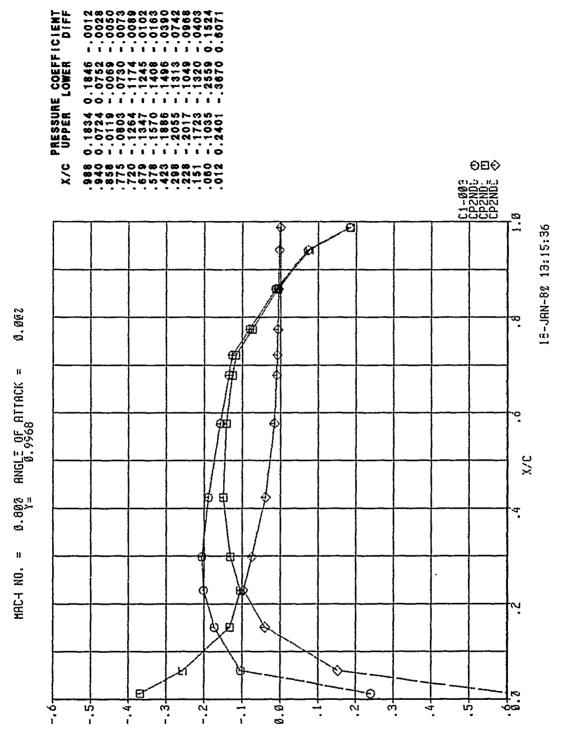


Figure 445, Chordwise Pressure Distribution, Steady, Configuration

 $C_{\mathbf{p}}$, pressure coefficient

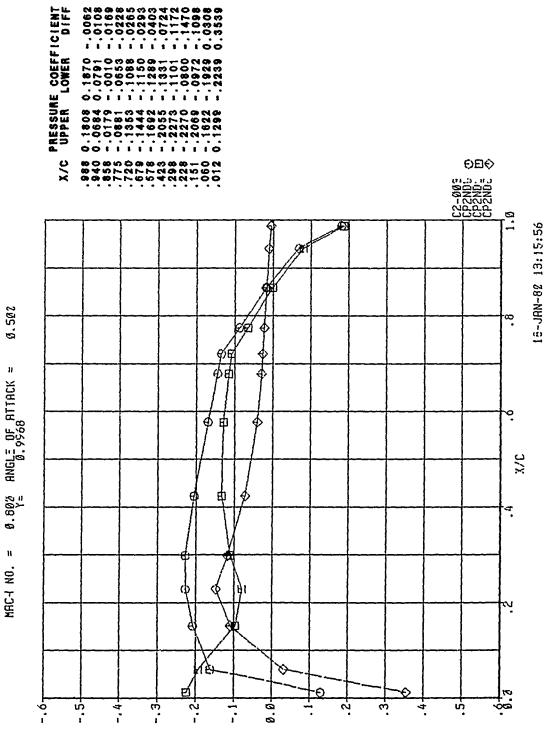


Figure 446, Chordwise Pressure Distribution, Steady, Configuration

1

 $c_{
m p}$, pressure coefficient

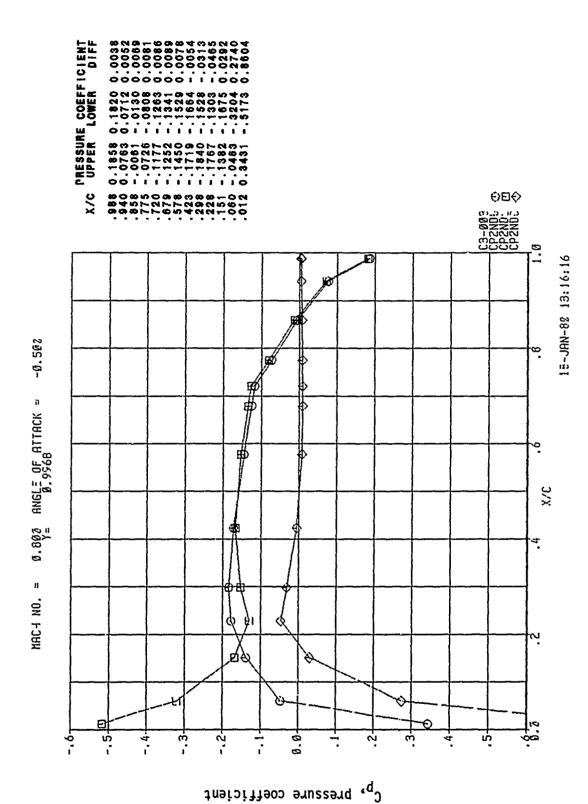


Figure 447, Chordwise Pressure Distribution, Steady, Configuration 5

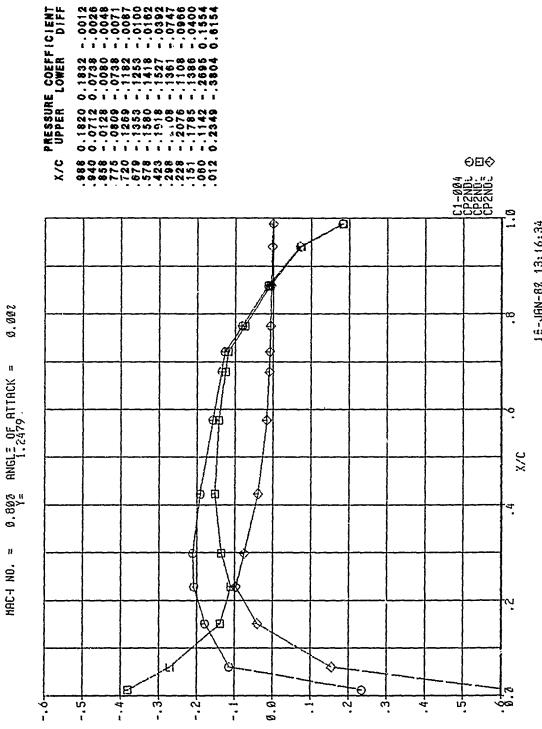


Figure 448, Chordwise Pressure Distribution, Steady, Configuration 5

 $c_{
m p}$, pressure coefficient

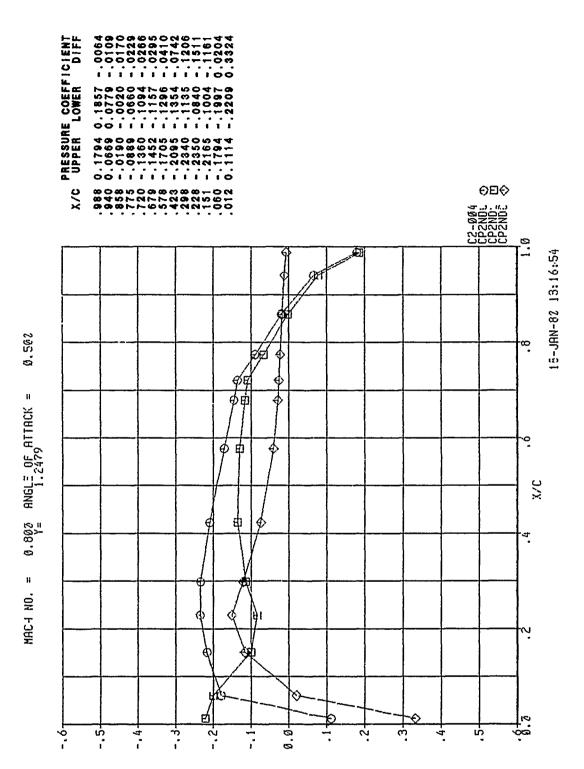


Figure 449, Chordwise Pressure Distribution, Steady, Configuratior 5

 $c_{\mathbf{p}}$, pressure coefficient

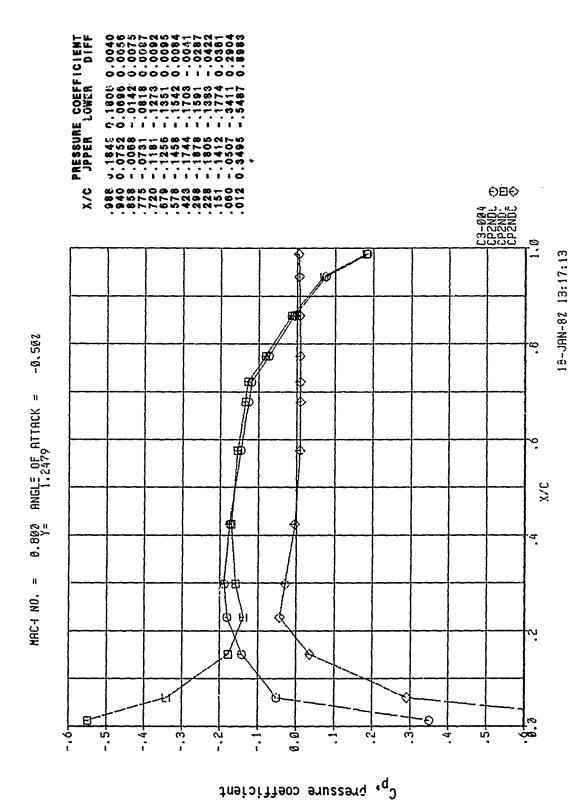


Figure 450, Chordwise Pressure Distribution, Steady, Configuration 5

.

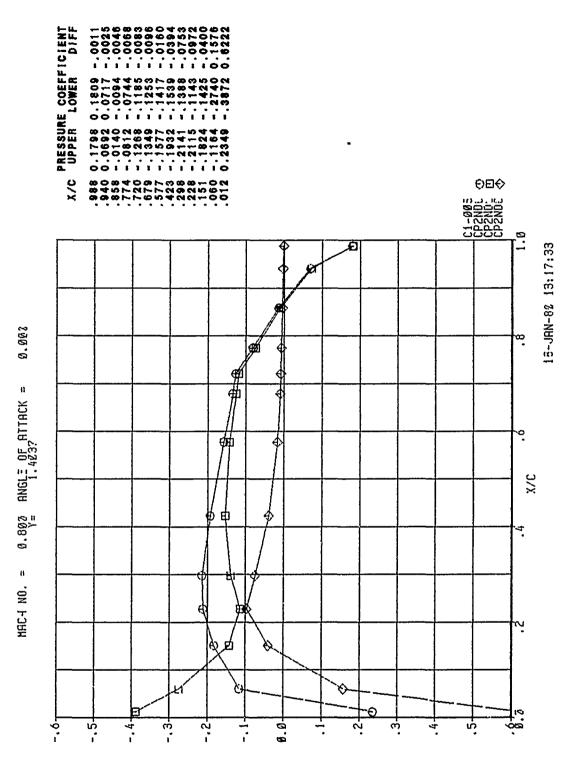


Figure 451, Chordwise Pressure Distribution, Steady, Configuration

 $\sigma_{\mathbf{p}}$, pressure coefficient

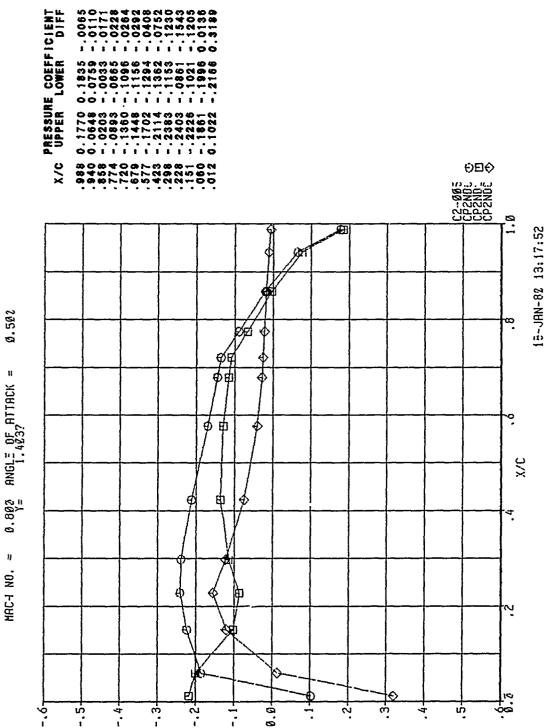


Figure 452, Chordwise Pressure Distribution, Steady, Configuration

C_p, pressure coefficient

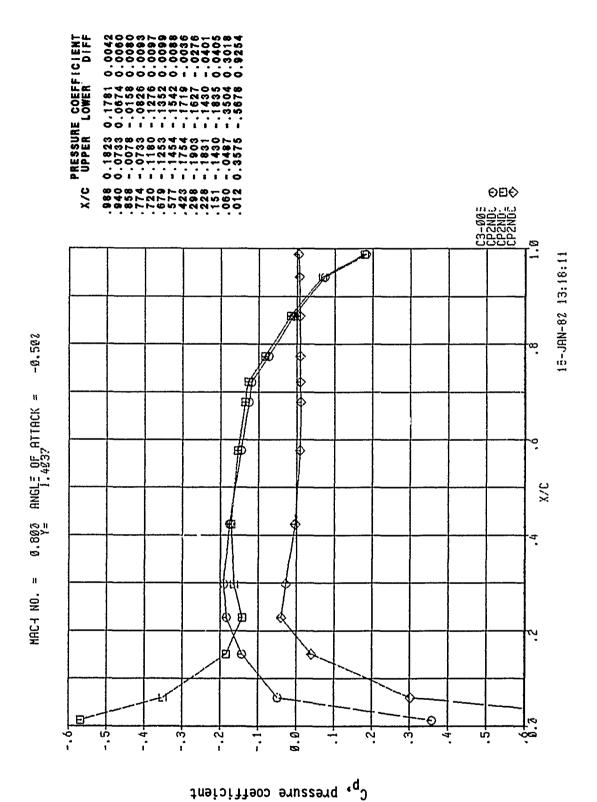
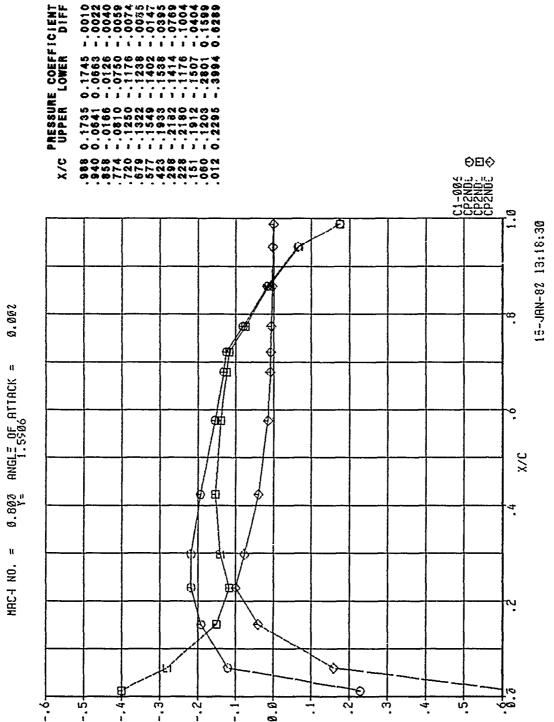


Figure 453, Chordwise Pressure Distribution, Steady, Configuration 5



ည

Figure 454, Chordwise Pressure Distribution, Steady, Configuration

 $\sigma_{\rm p}$ pressure coefficient

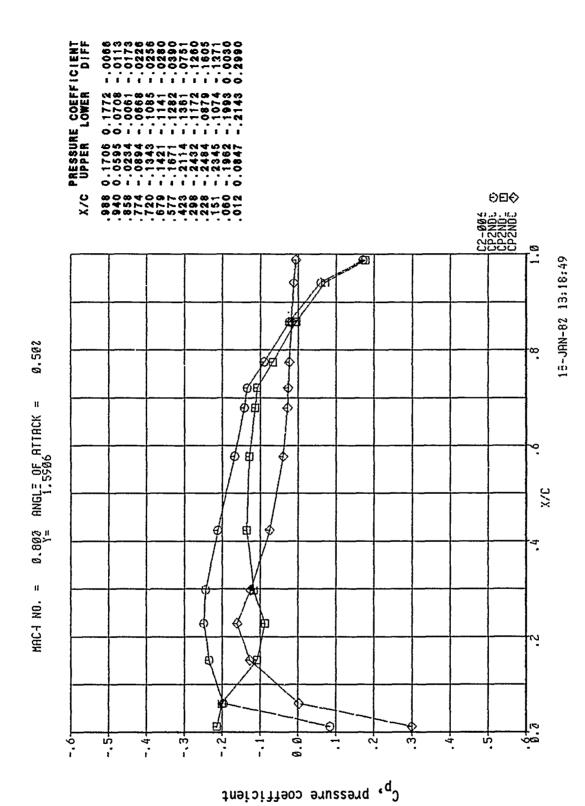


Figure 455, Chordwise Pressure Distribution, Steady, Configuration 5

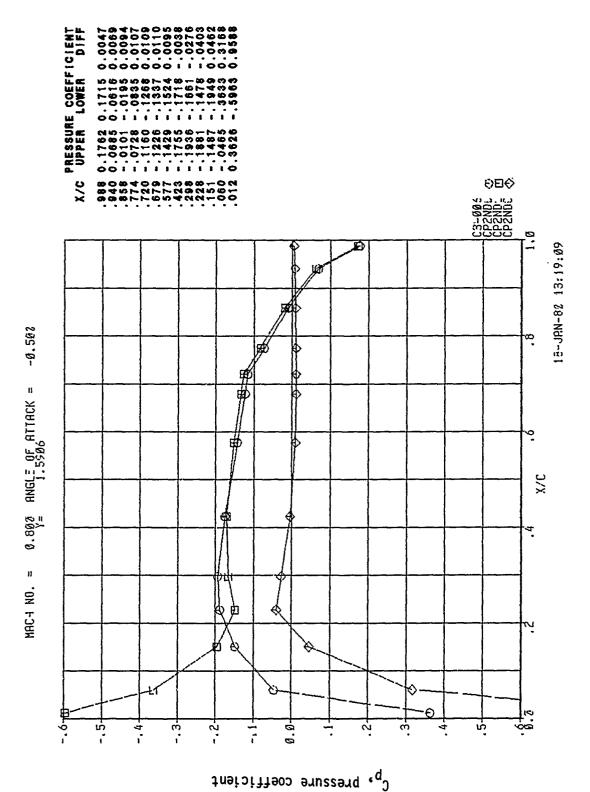


Figure 456, Chordwise Pressure Distribution, Steady, Configuration

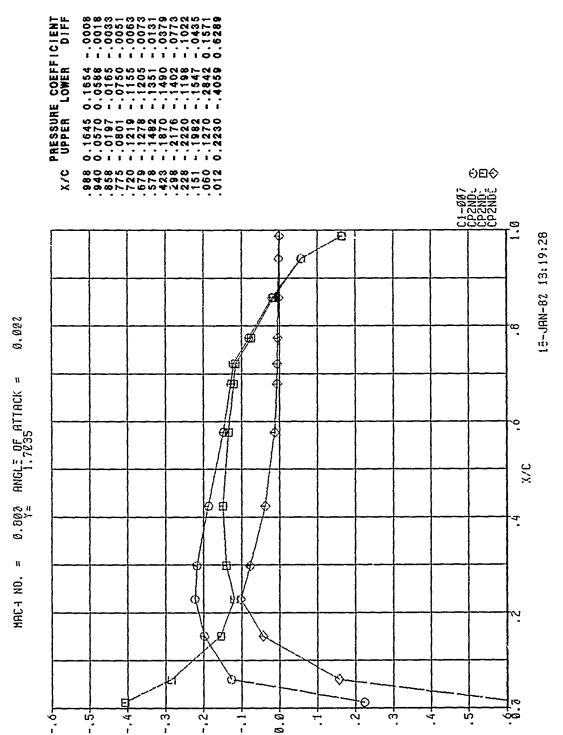


Figure 457, Chordwise Pressure Distribution, Steady, Configuration

 $c_{
m p}$, pressure coefficient

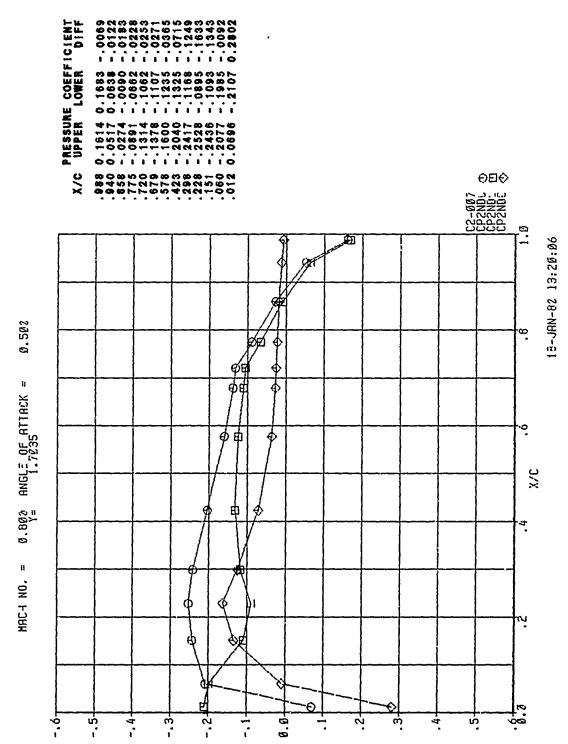
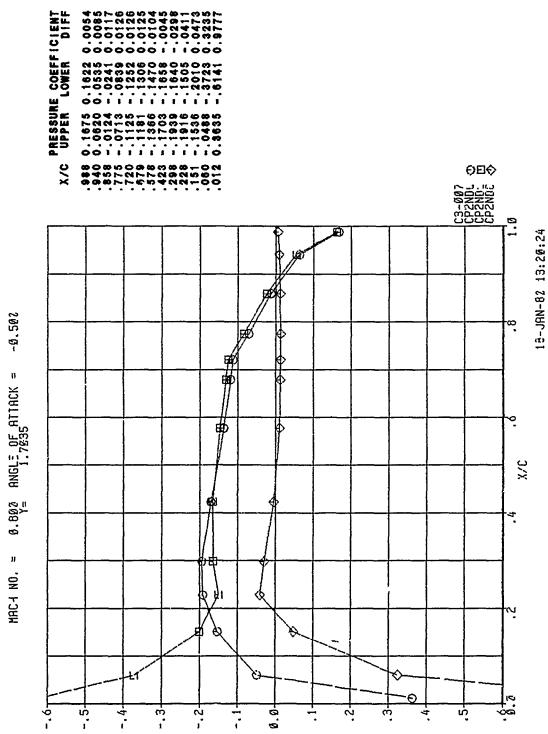


Figure 458, Chordwise Pressure Distribution, Steady, Configuration

 $c_{
m p}$, pressure coefficient



459, Chordwise Pressure Distribution, Steady, Configuration

Figure

C_p, pressure coefficient

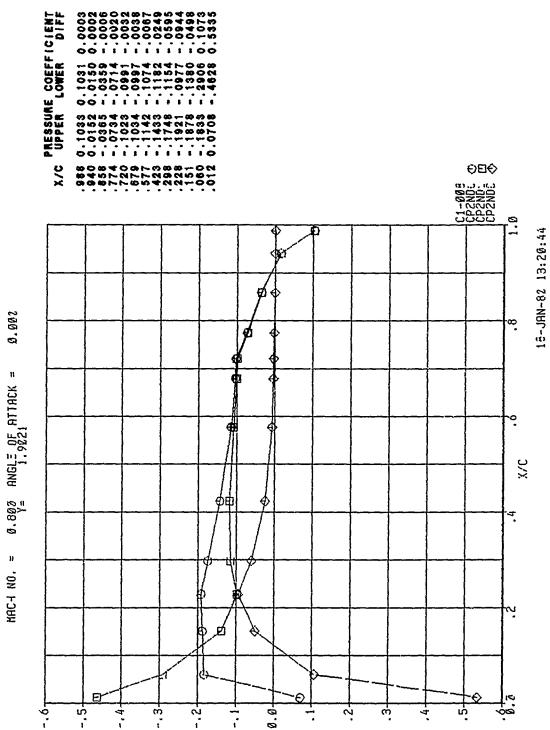
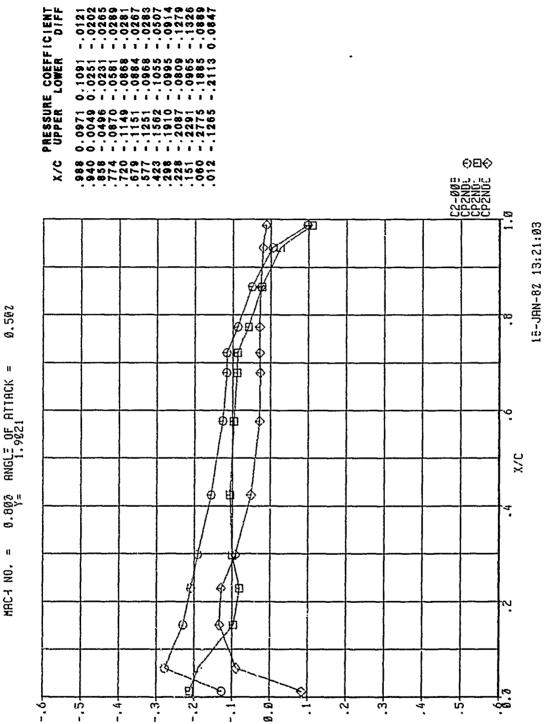


Figure 460, Chordwise Pressure Distribution, Steady, Configuration

C_p, pressure coefficient



ည

Figure 461, Chordwise Pressure Distribution, Steady, Configuration

 $\textbf{C}_{\textbf{p}}\text{,}$ pressure coefficient

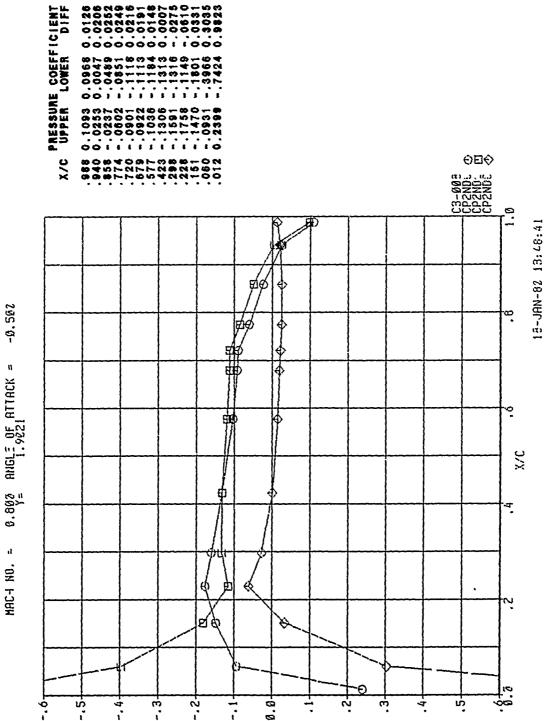


Figure 462, Chordwise Pressure Distribution, Steady, Configuration

 $c_{\mathbf{p}}$, pressure coefficient

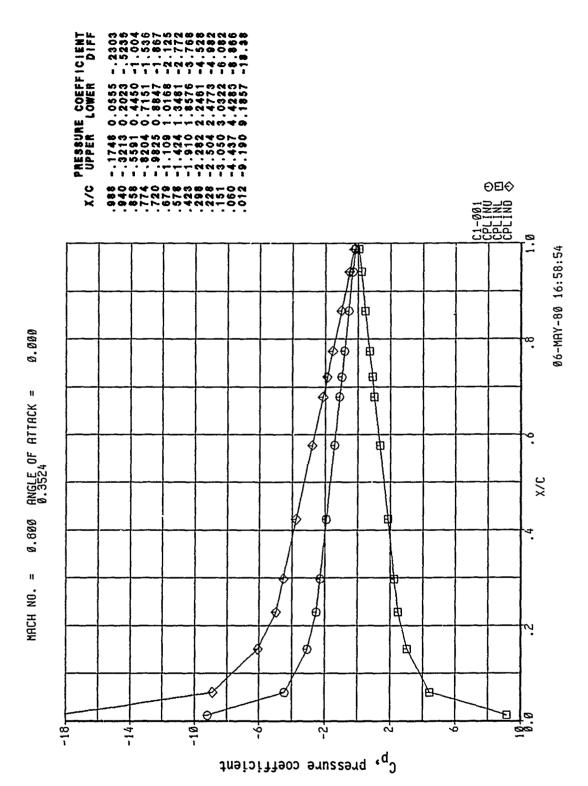


Figure 463, Chordwise Pressure Distribution, Real, Configuration 5

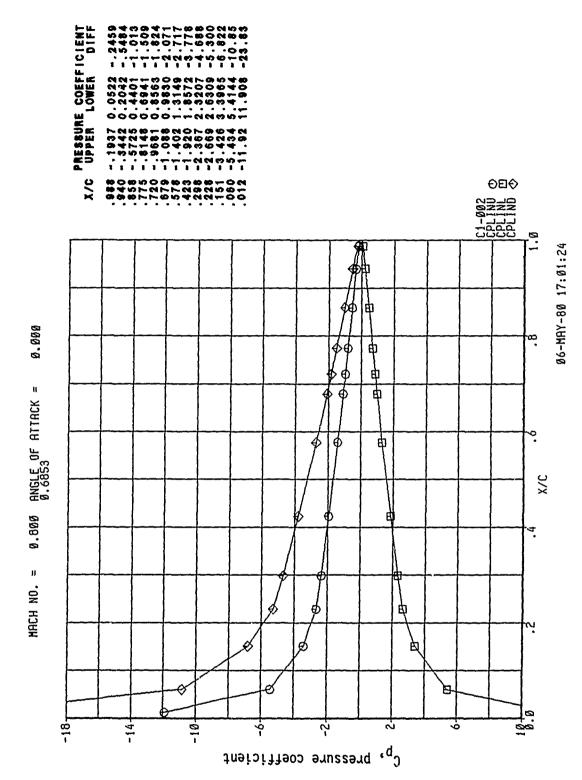
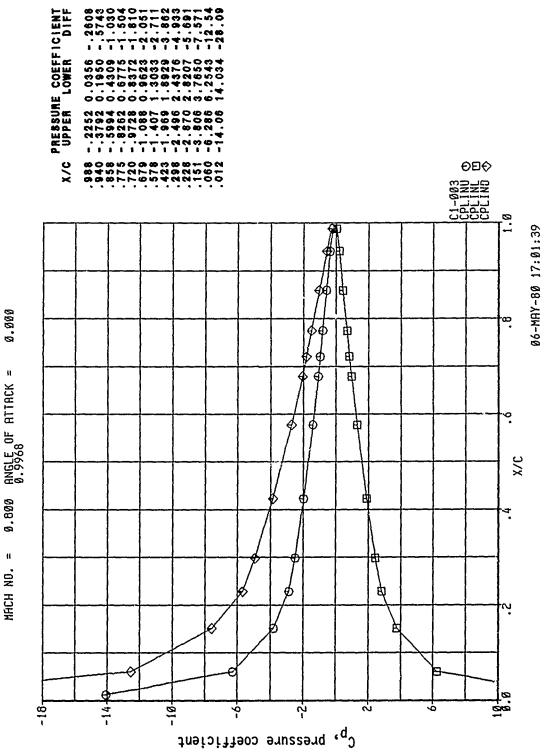


Figure 464, Chordwise Pressure Distribution, Real, Configuration 5



0.800

MACH NO.

Figure 465, Chordwise Pressure Distribution, Real, Configuration

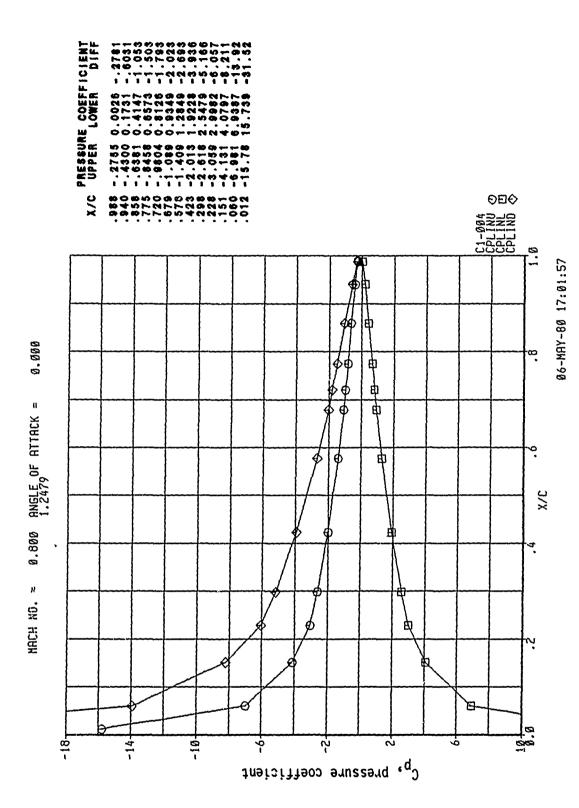


Figure 466, Chordwise Pressure Distribution, Real, Configuration 5

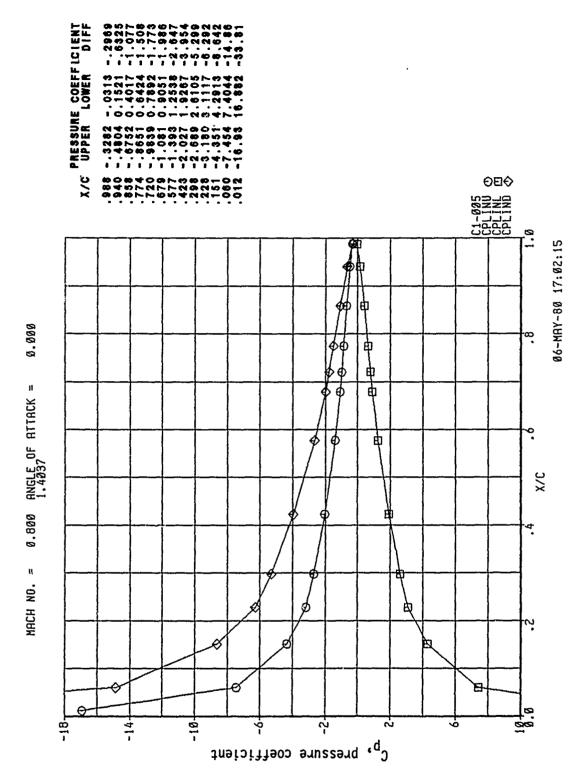
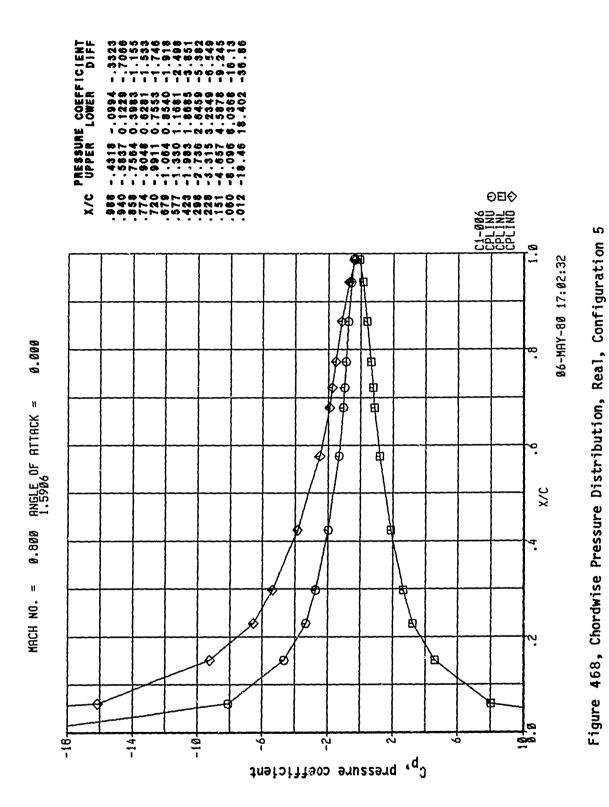


Figure 467, Chordwise Pressure Distribution, Real, Configuration 5



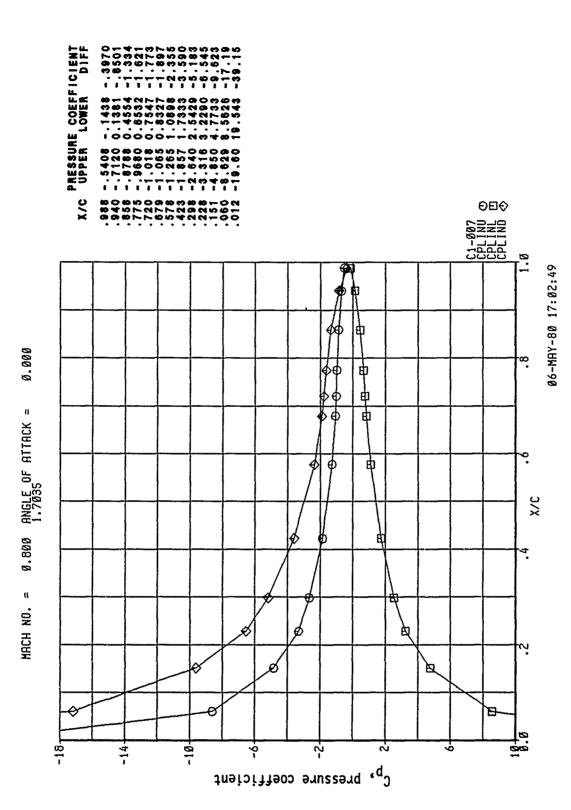


Figure 469, Chordwise Pressure Distribution, Real, Configuration 5

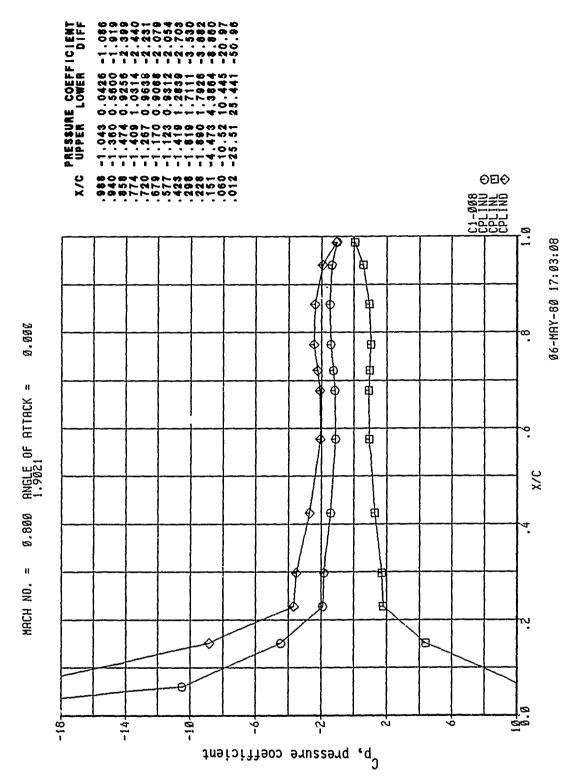
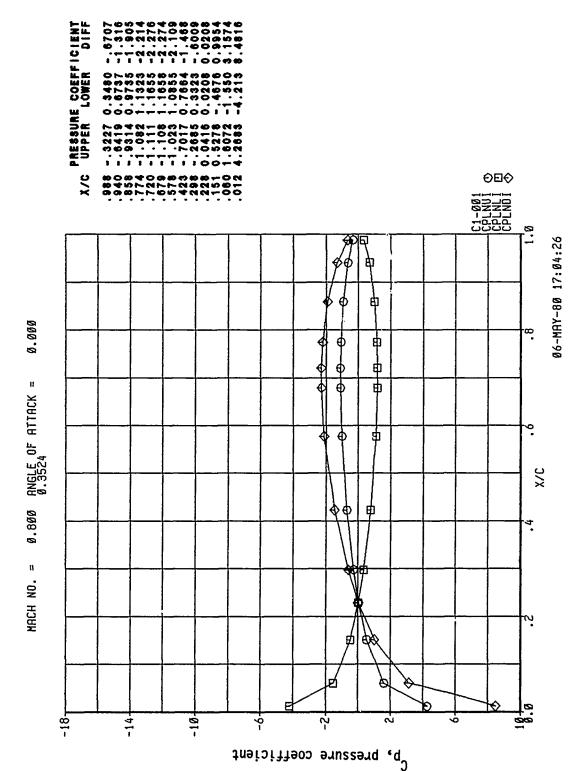


Figure 470, Chordwise Pressure Distribution, Real, Configuration 5



S Figure 471, Chordwise Pressure Distribution, Imaginary, Configuration

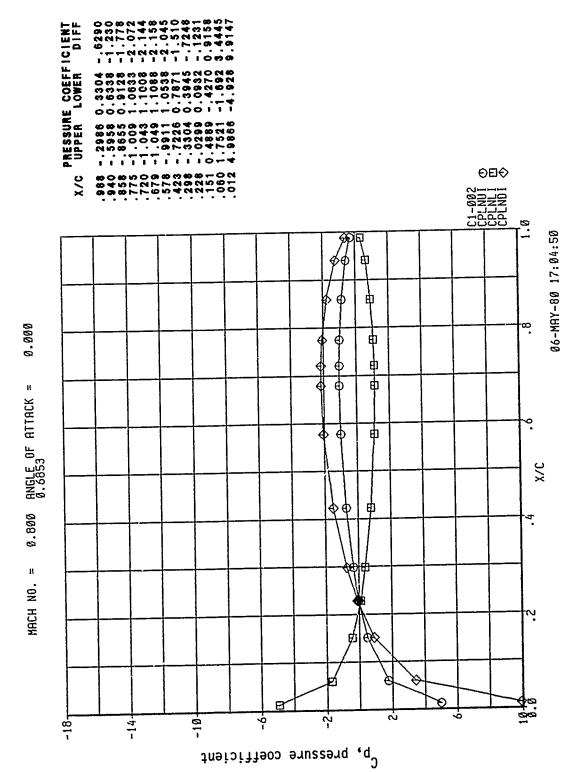


Figure 472, Chordwise Pressure Distribution, Imaginary, Configuration

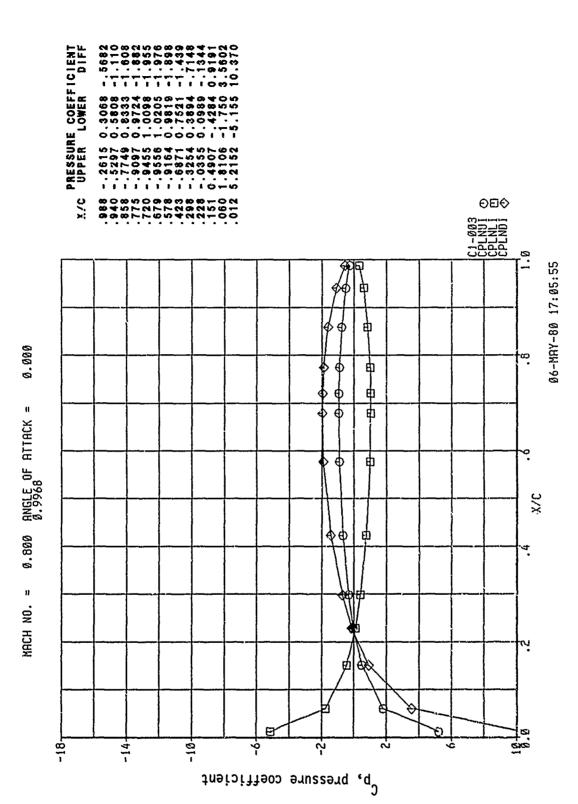


Figure 473, Chordwise Pressure Distribution, Imaginary, Configuration

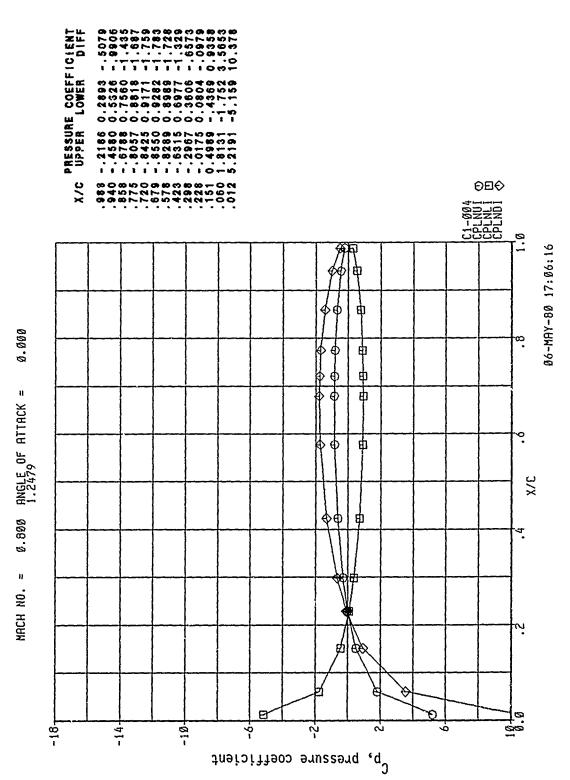


Figure 474, Chordwise Pressure Distribution, Imaginary, Configuration

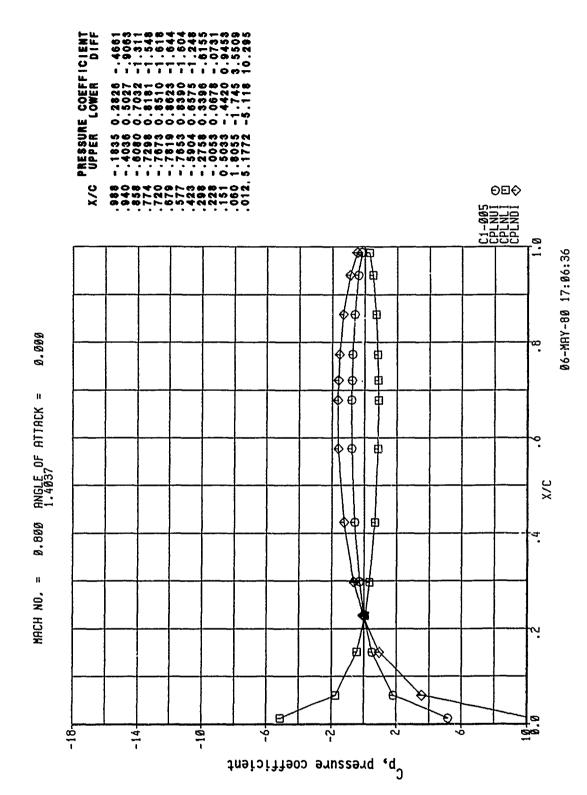
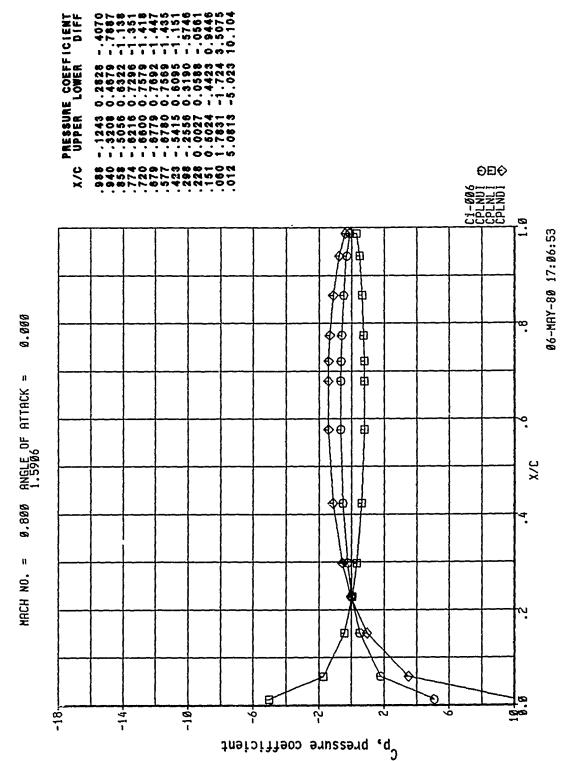
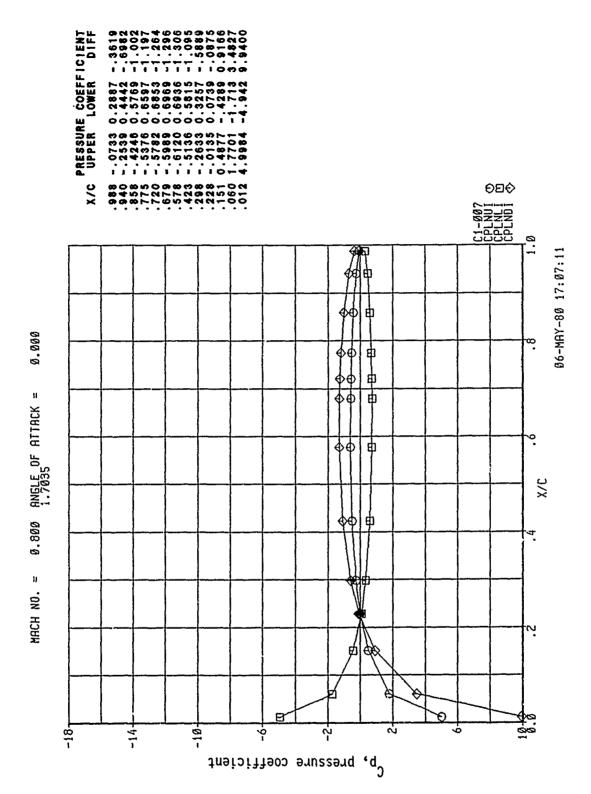


Figure 475, Chordwise Pressure Distribution, Imaginary, Configuration 5



S Figure 476, Chordwise Pressure Distribution, Imaginary, Configuration



വ 477, Chordwise Pressure Distribution, Imaginary, Configuration Figure

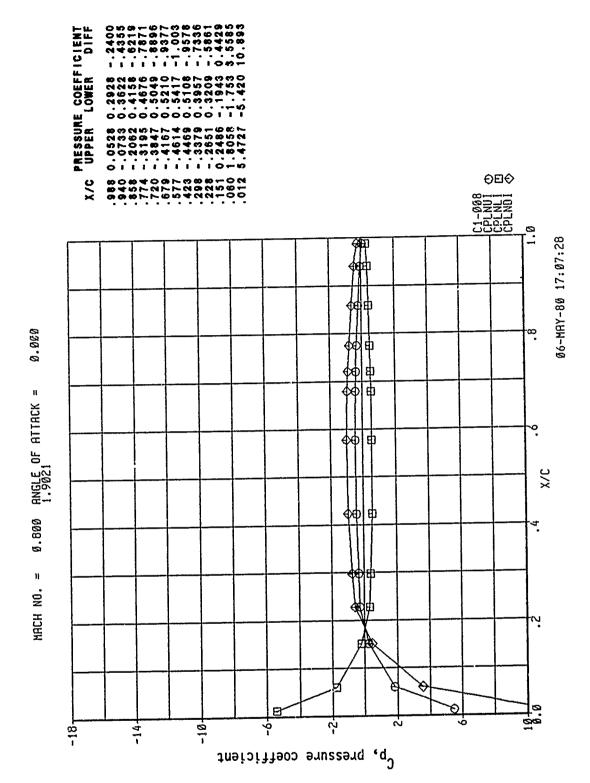
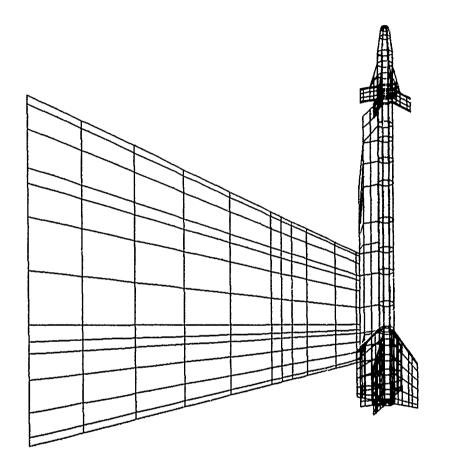
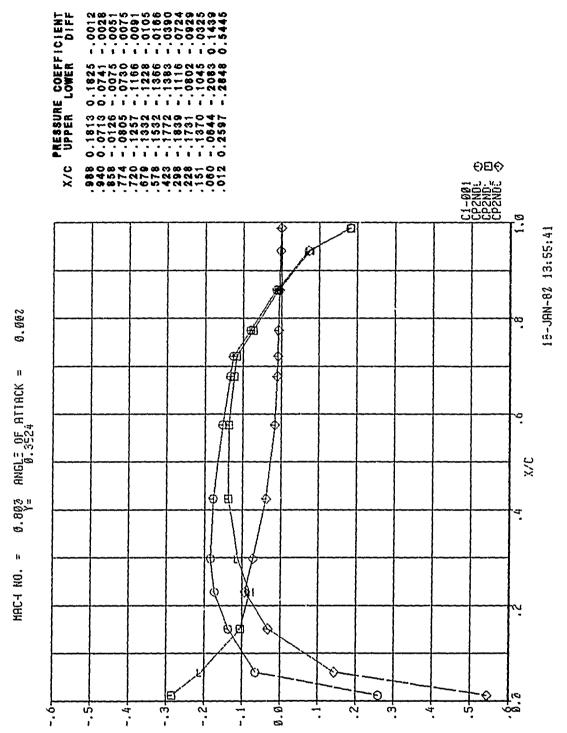


Figure 478, Chordwise Pressure Distribution, Imaginary, Configuration





9

Figure 480, Chordwise Pressure Distribution, Steady, Configuration

fneisiT7eos enusserq _{(q}0

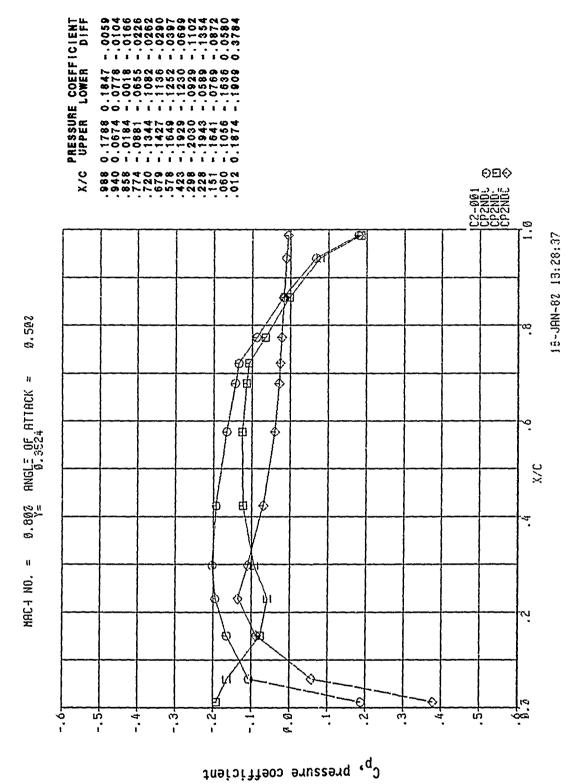


Figure 481, Chordwise Pressure Distribution, Steady, Configuration

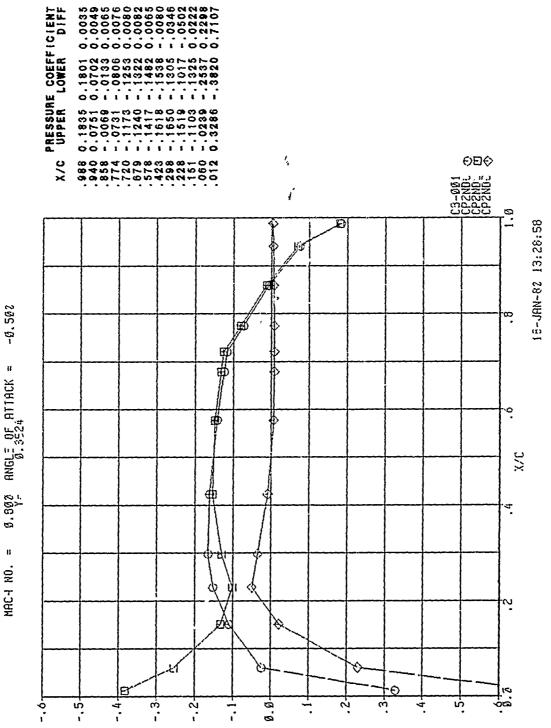


Figure 482, Chordwise Pressure Distribution, Steady, Configuration 6

 c_{p} , pressure coefficient

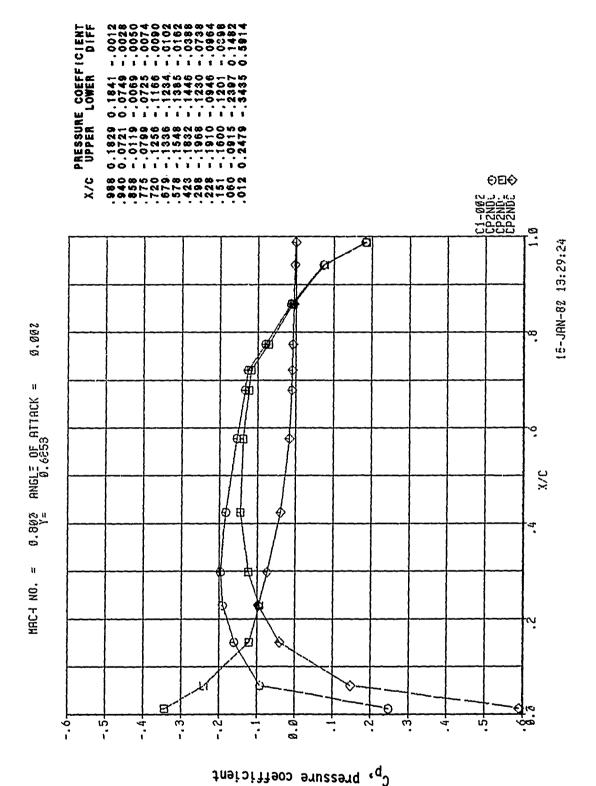


Figure 483, Chordwise Pressure Distribution, Steady, Configuration

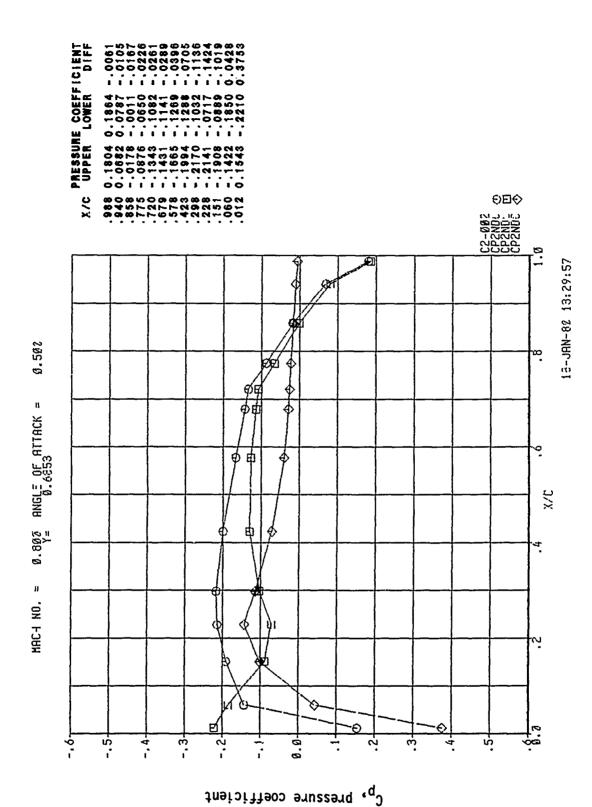


Figure 484, Chordwise Pressure Distribution, Steady, Configuration

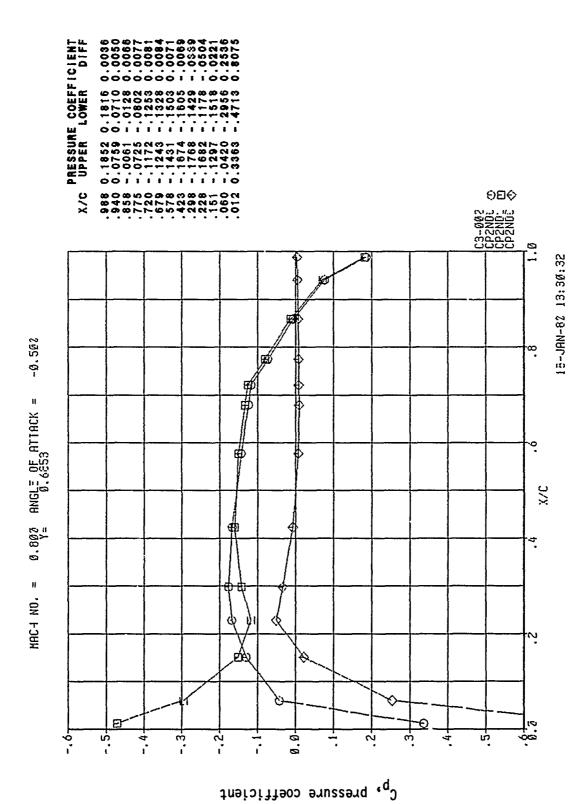


Figure 485, Chordwise Pressure Distribution, Steady, Configuration

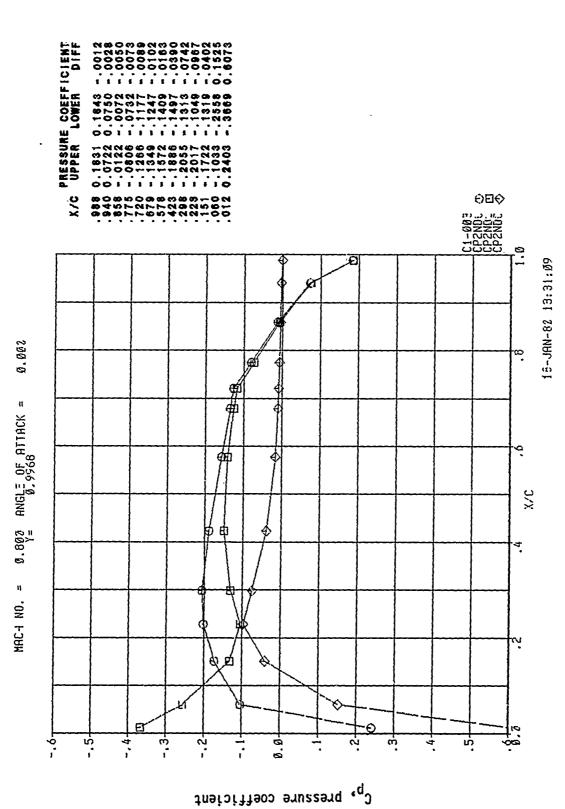


Figure 486, Chordwise Pressure Distribution, Steady, Configuration 6

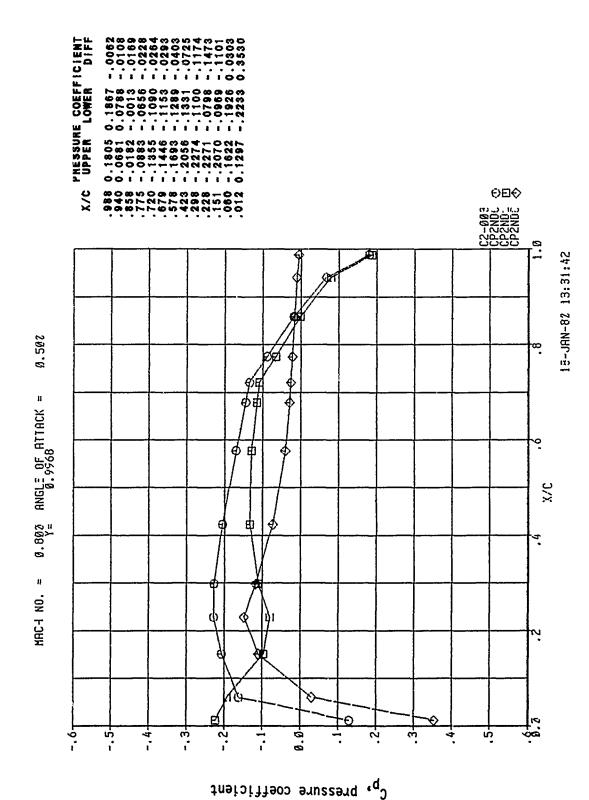


Figure 487, Chordwise Pressure Distribution, Steady, Configuration 6

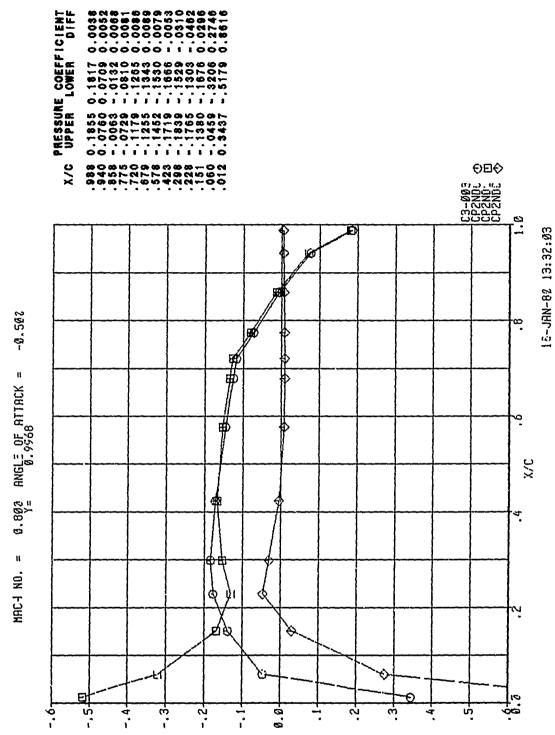


Figure 488, Chordwise Pressure Distribution, Steady, Configuration

C_p, pressure coefficient

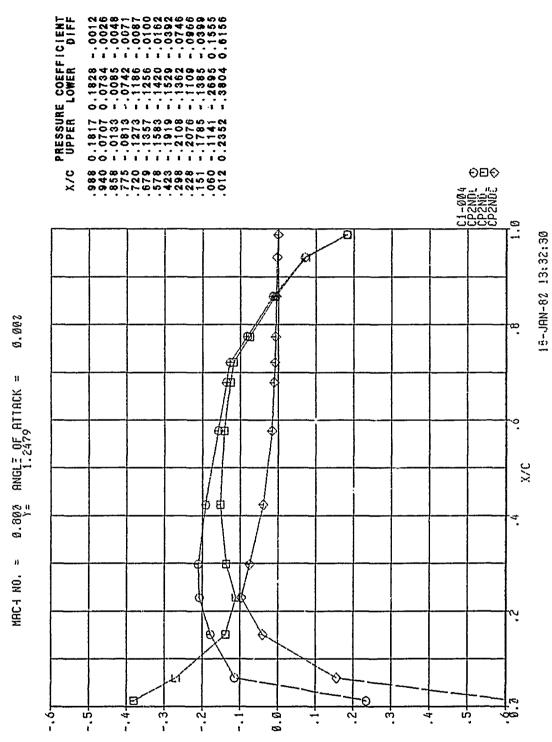


Figure 489, Chordwise Pressure Distribution, Steady, Configuration

 $\sigma_{\rm p}$, pressure coefficient

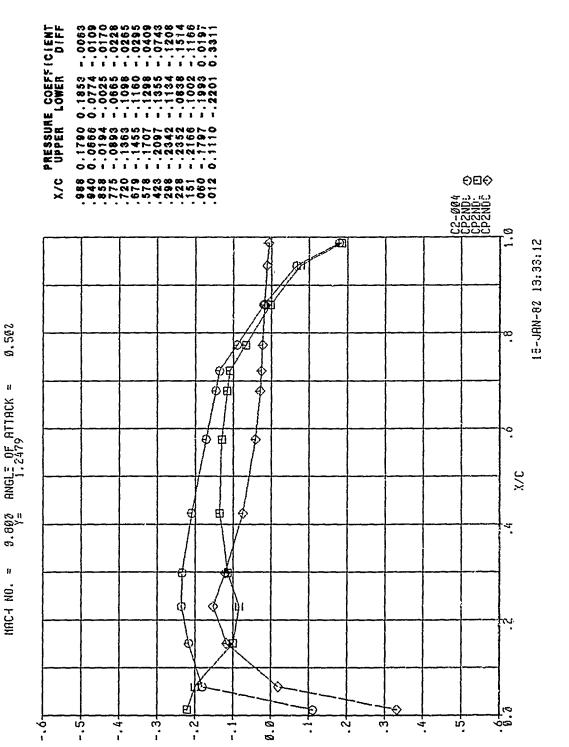


Figure 490, Chordwise Pressure Distribution, Steady, Configuration

Jusisitteos erussard _td

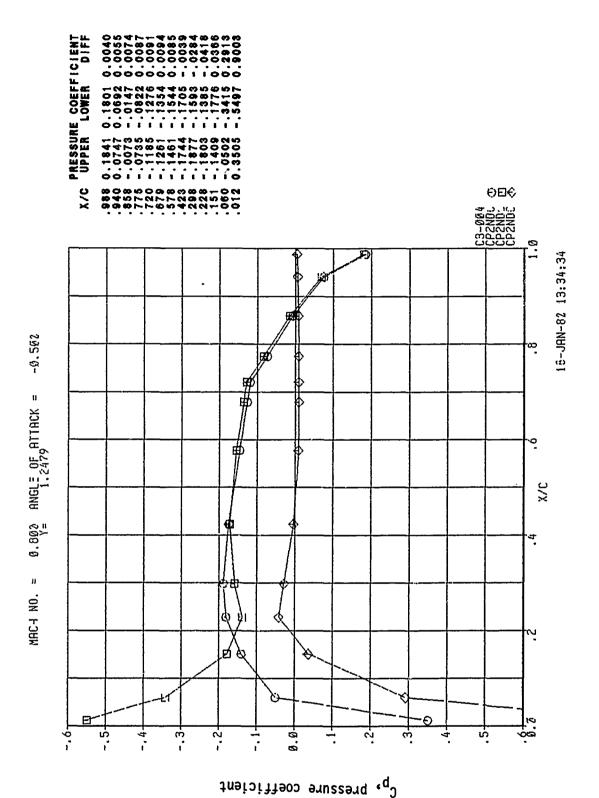


Figure 491, Chordwise Pressure Distribution, Steady, Configuration 6

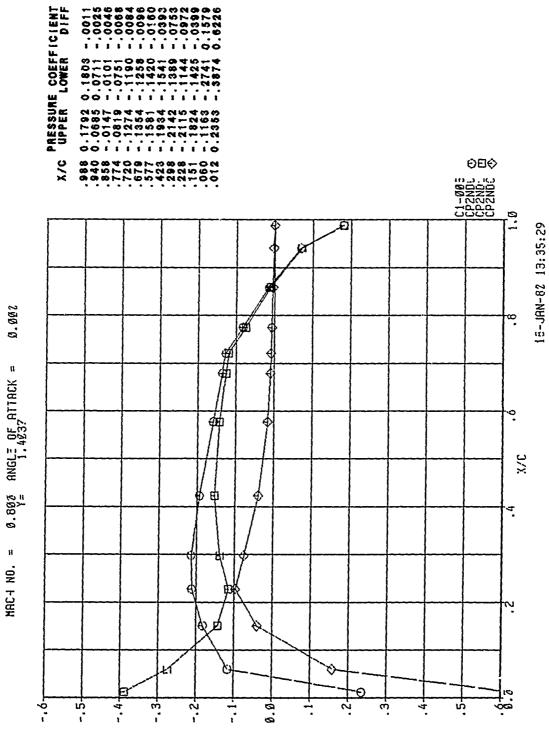


Figure 492, Chordwise Pressure Distribution, Steady, Configuration 6

 $C_{\mathbf{p}}$, pressure coefficient

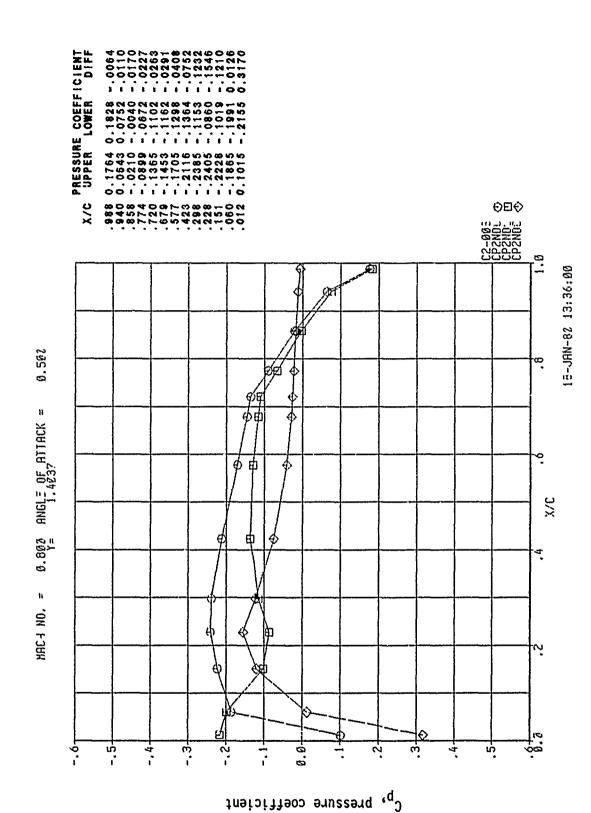


Figure 493, Chordwise Pressure Distribution, Steady, Configuration 6

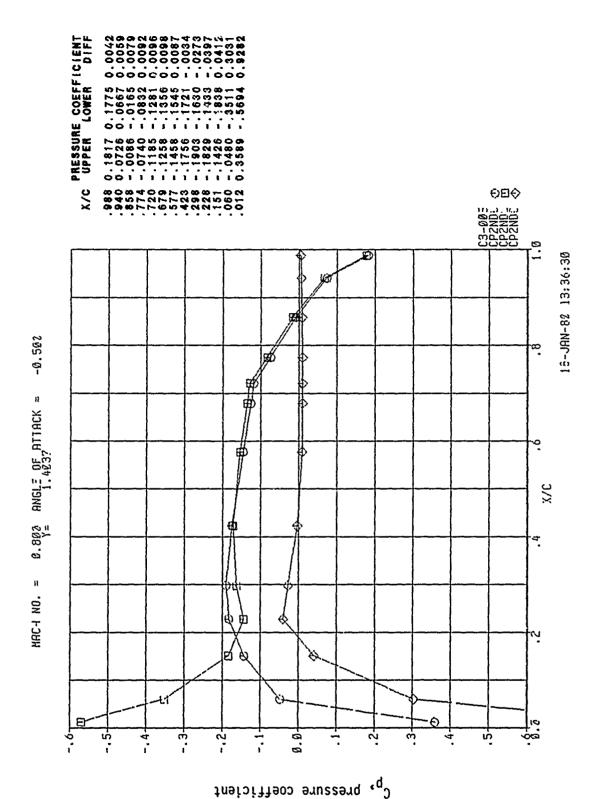


Figure 494, Chordwise Pressure Distribution, Steady, Configuration 6

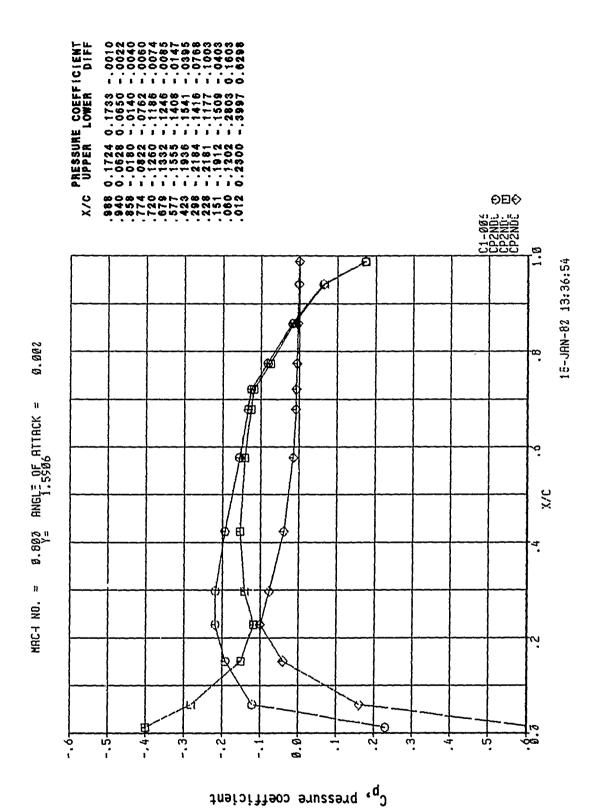


Figure 495, Chordwise Pressure Distribution, Steady, Configuration 6

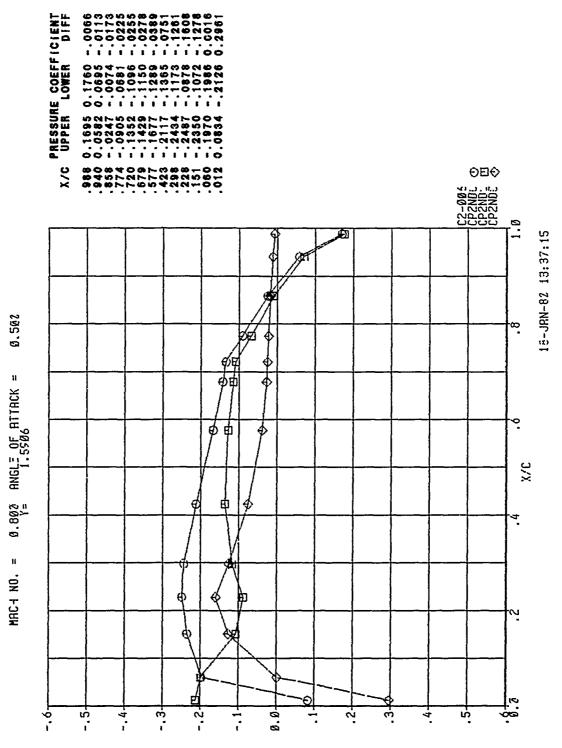


Figure 496, Chordwise Pressure Distribution, Steady, Configuration

C_p, pressure coefficient

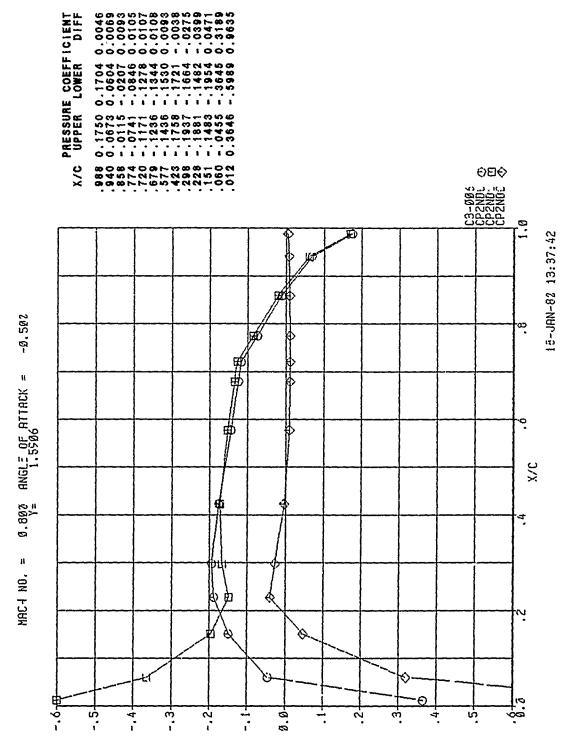


Figure 497, Chordwise Pressure Distribution, Steady, Configuration

 C_{p} , pressure coefficient

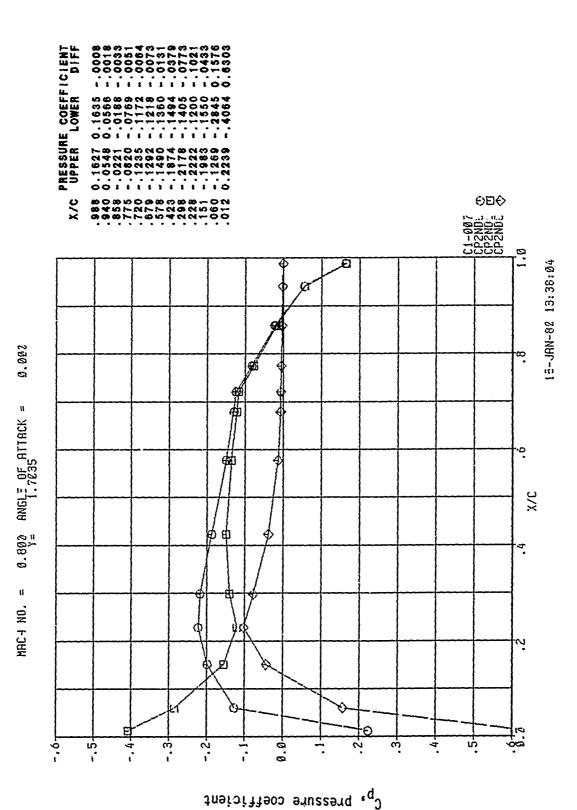


Figure 498, Chordwise Pressure Distribution, Steady, Configuration 6

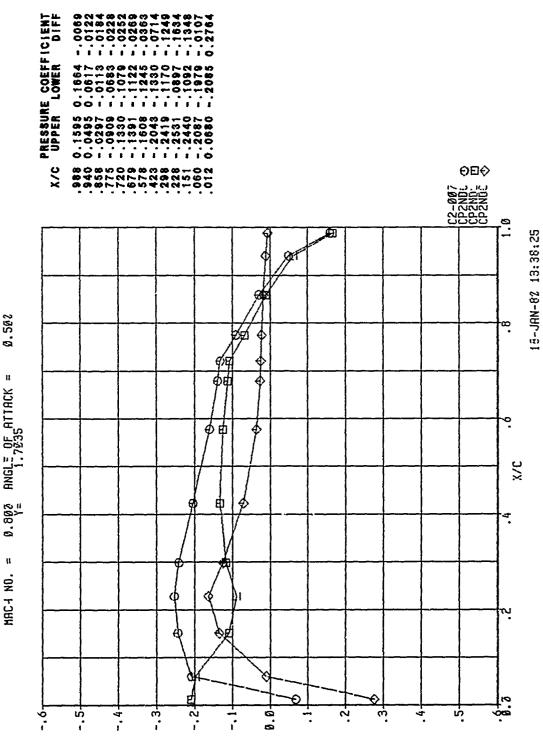


Figure 499, Chordwise Pressure Distribution, Steady, Configuration

C_p, pressure coefficient

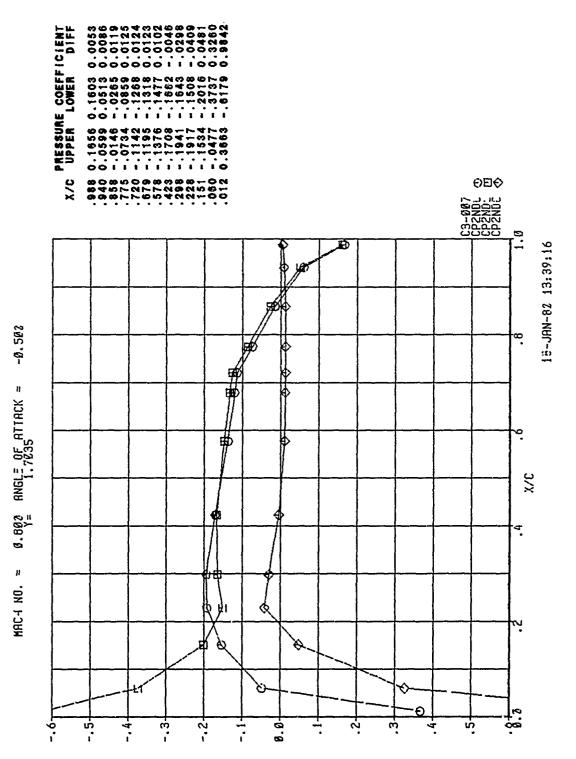
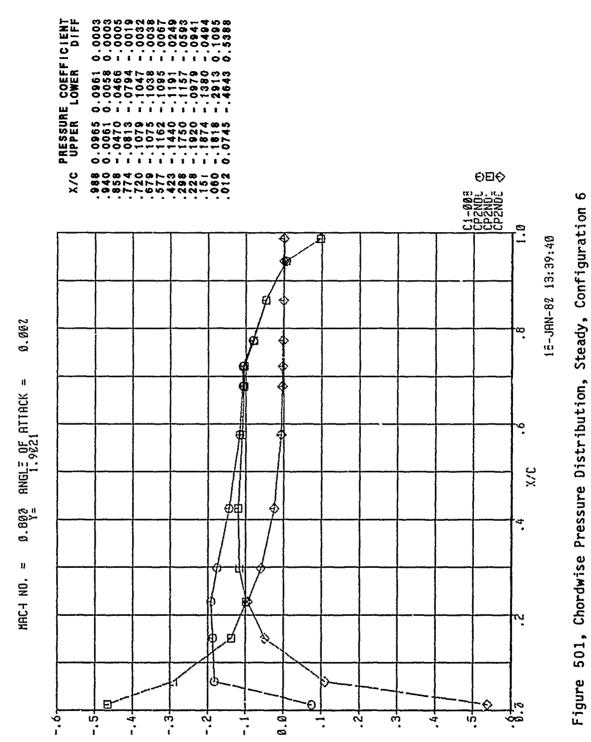


Figure 500, Chordwise Pressure Distribution, Steady, Configuration 6

 $C_{\mathbf{p}}$, pressure coefficient



 $c_{
m p}$, pressure coefficient

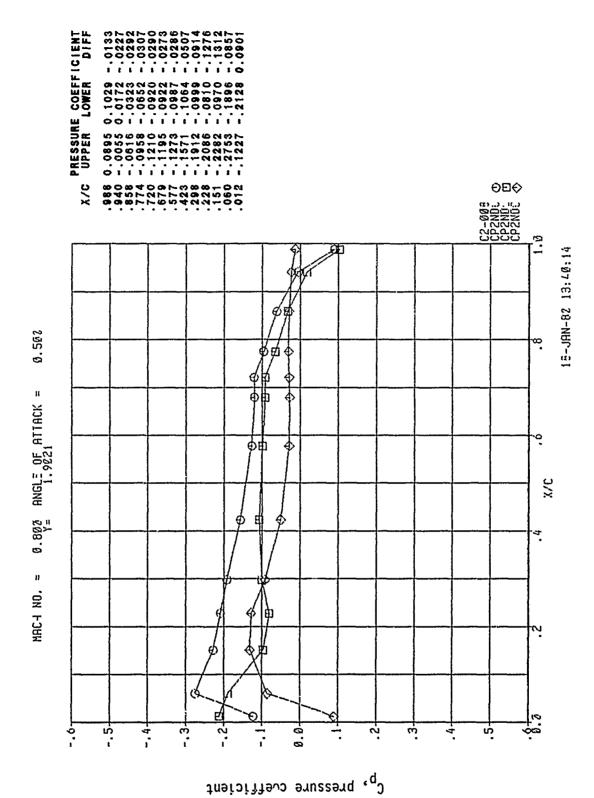
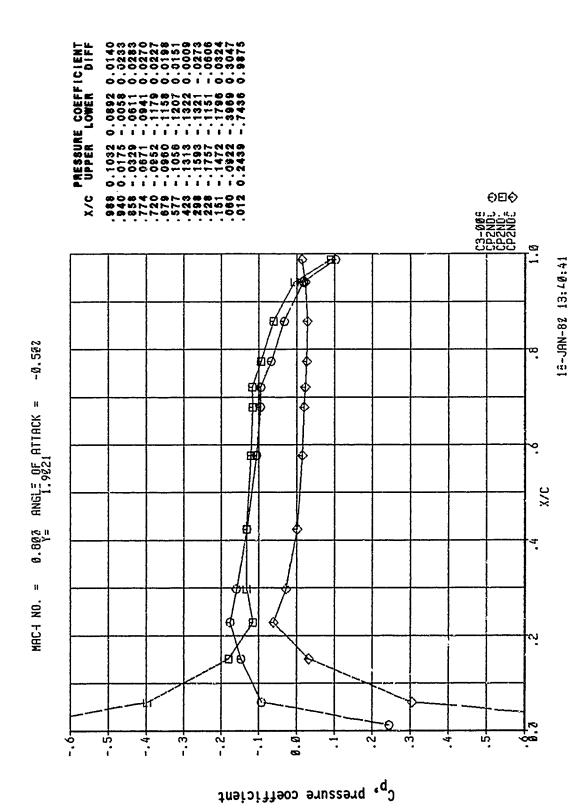
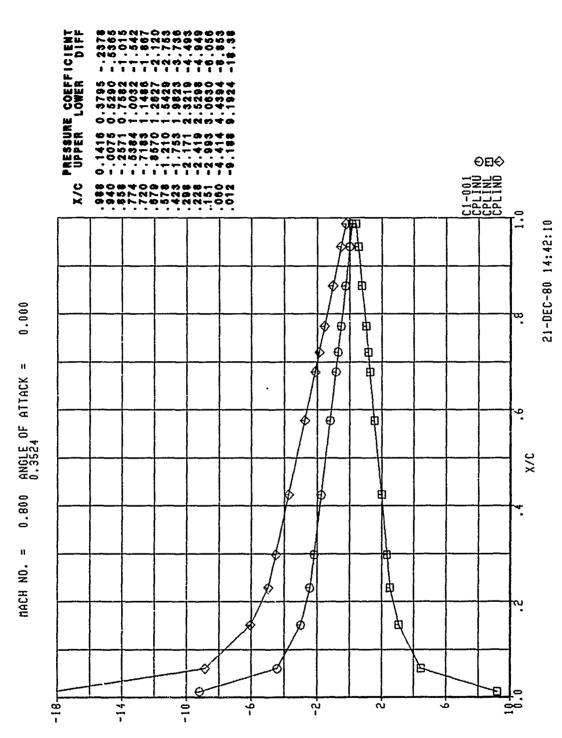


Figure 502, Chordwise Pressure Distribution, Steady, Configuration



9 Figure 503, Chordwise Pressure Distribution, Steady, Configuration

and the state att the time the state of the



Pressure Distribution, Real Configuration

 $C_{\mathbf{p}}$, pressure coefficient

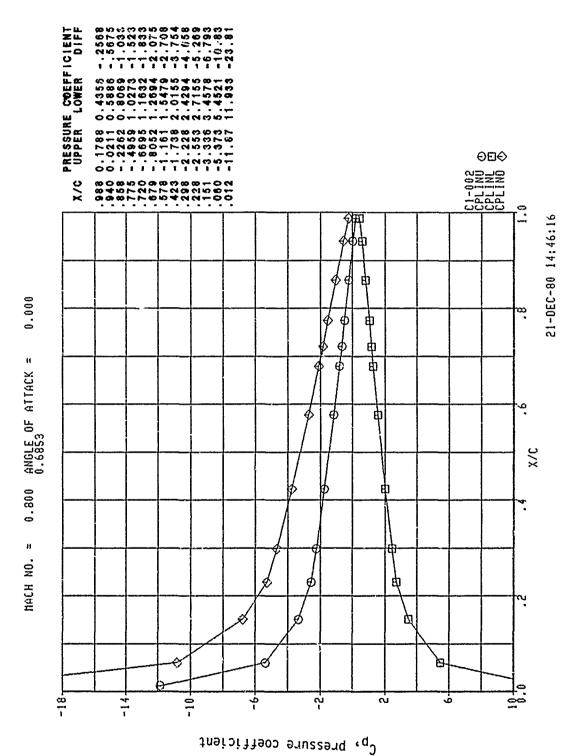


Figure 505, Chordwise Pressure Distribution, Real Configuration 6

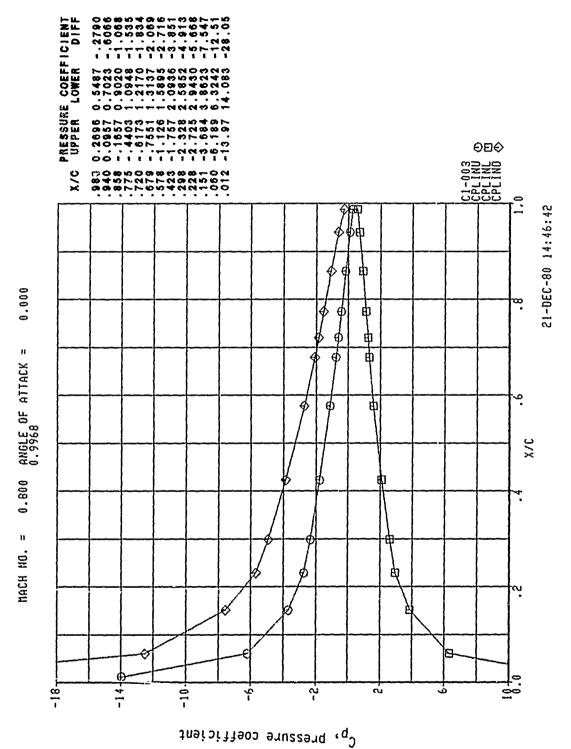


Figure 505, Chordwise Pressure Distribution, Real Configuration

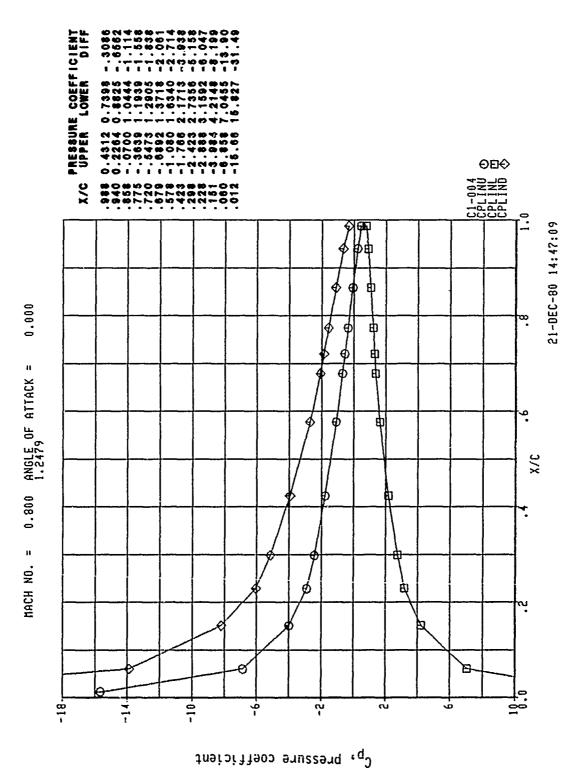


Figure 507, Chordwise Pressure Distribution, Real Configuration 6

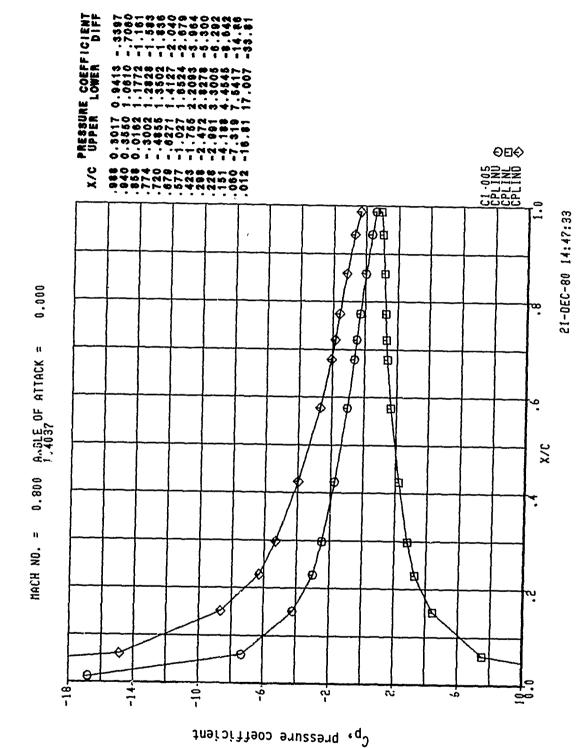


Figure 503. Chordwise Pressure Distribution, Real Configuration

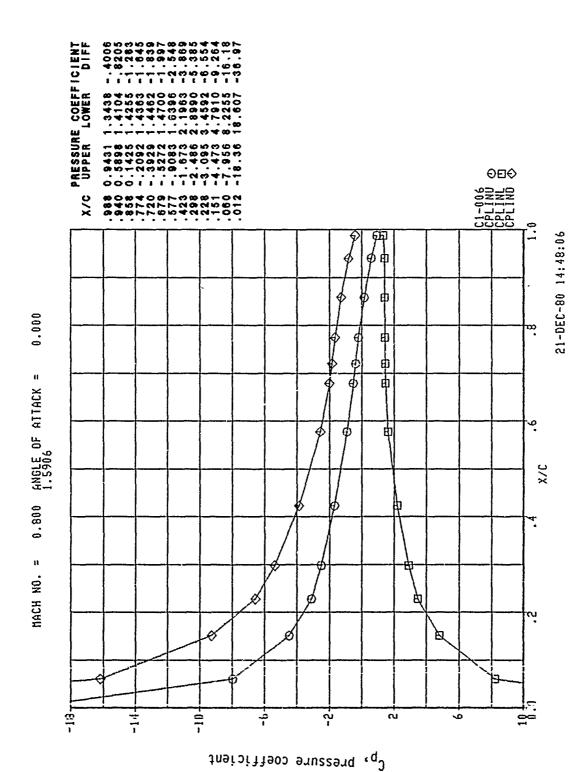


Figure 505, Chordwise Pressure Distribution, Real Configuration 6

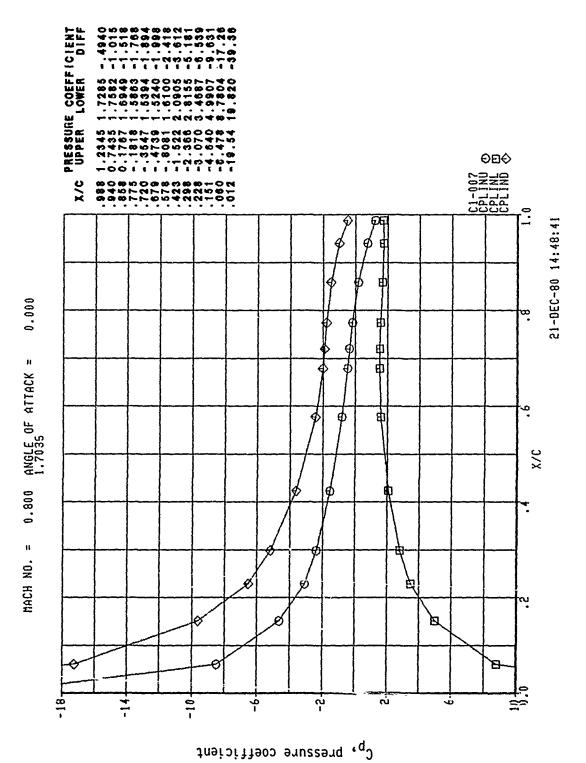


Figure 510, Chordwise Pressure Distríbution, Real Configuration

Figure 511, Chordwise Pressure Distribution, Real Configuration 6

21-DEC-80 14:49:04

3/x

⊕⊟⊕

 C_{p} , pressure coefficient

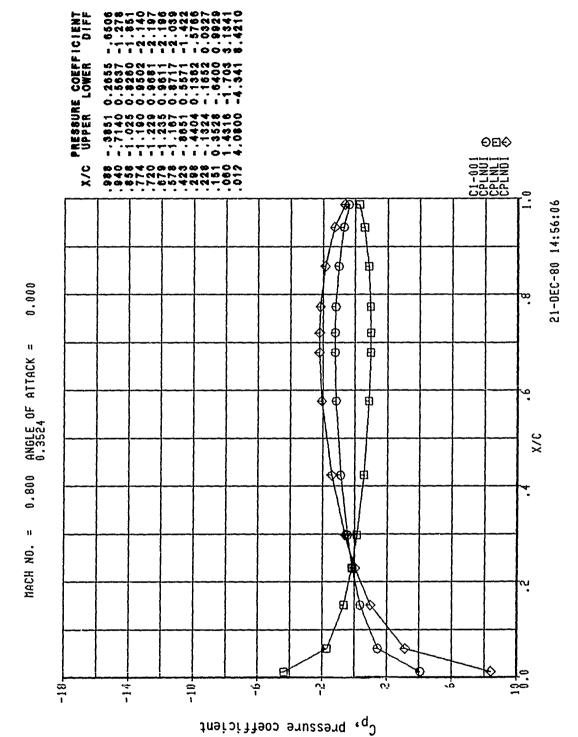


Figure 512, Chordwise Pressure Distribution, Imaginary Configuration

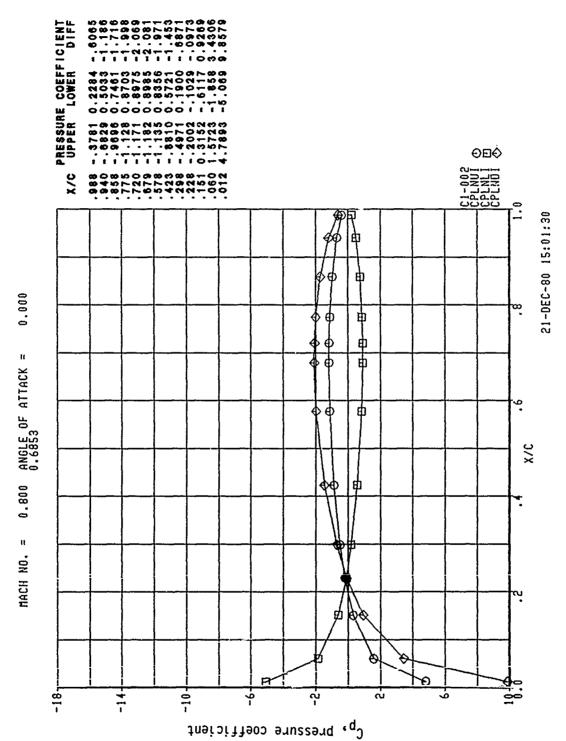


Figure 513, Chordwise Pressure Distribution, Imaginary Configuration

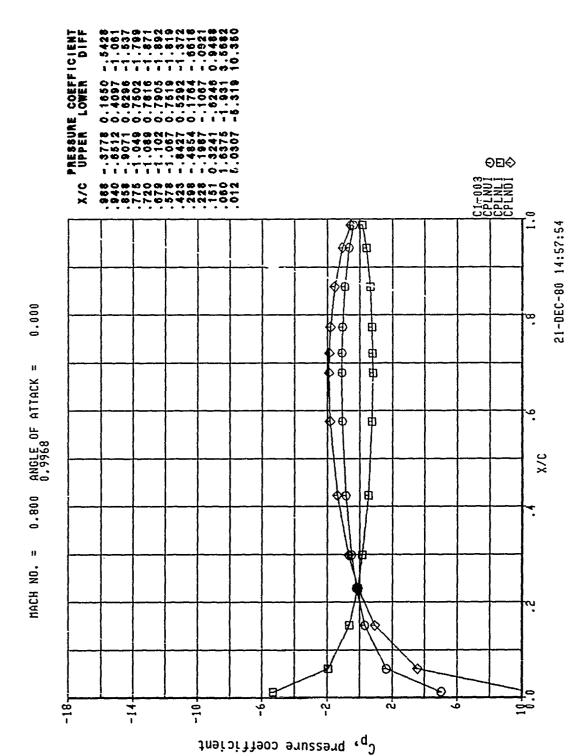


Figure 514, Chordwise Pressure Distribution, Imaginary Configuration

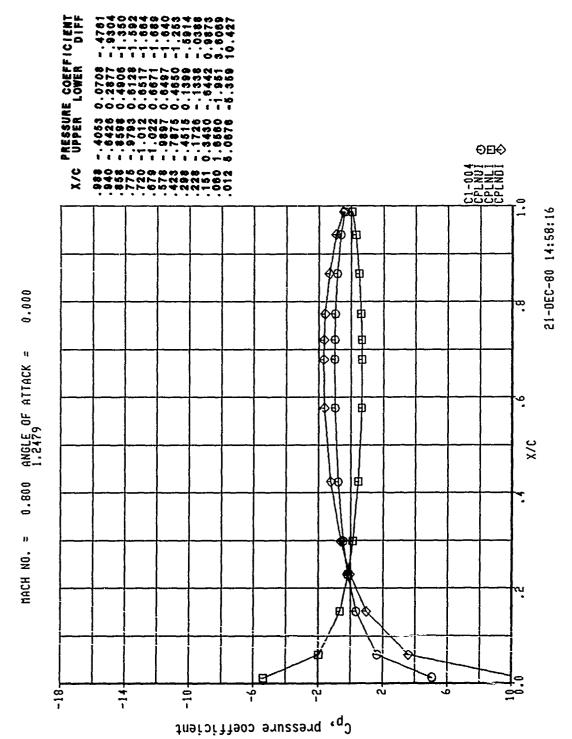


Figure 515, Chordwise Pressure Distribution, Imaginary Configuration

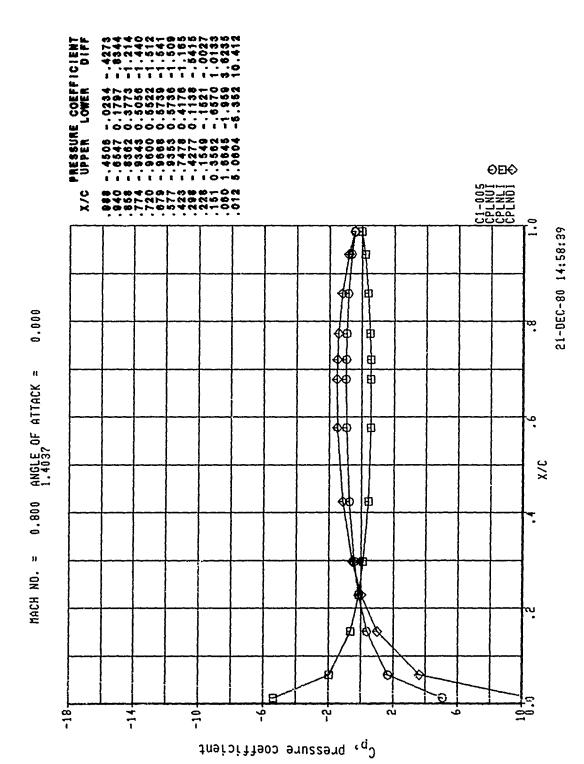


Figure 516, Chordwise Pressure Distribution, Imaginary Configuration 6

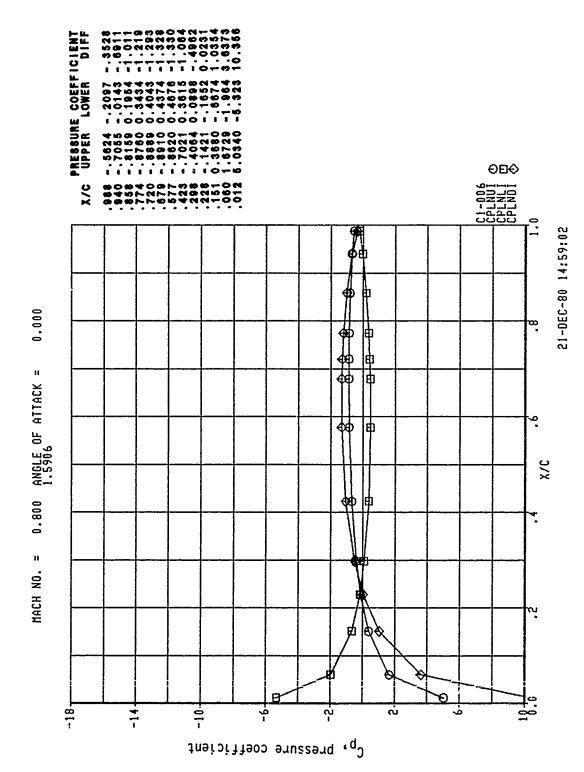


Figure 517, Chordwise Pressure Distribution, Imaginary Configuration

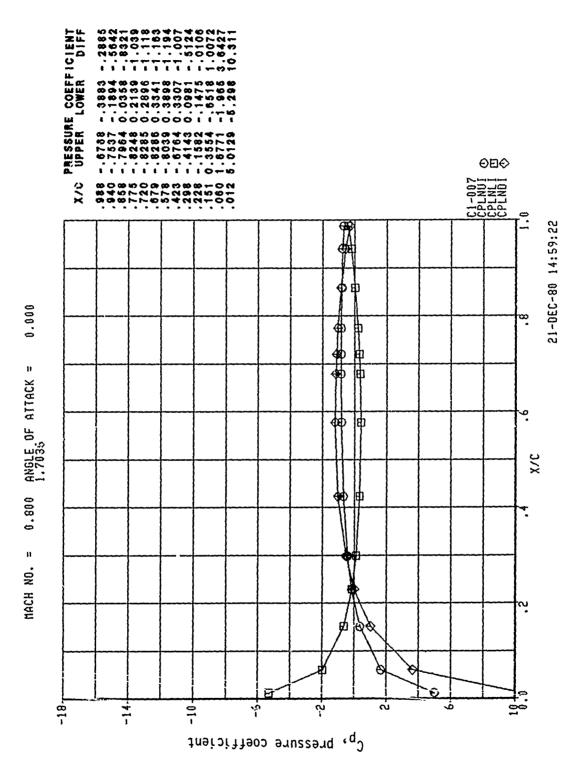


Figure 518, Chordwise Pressure Distribution, Imaginary Configuration

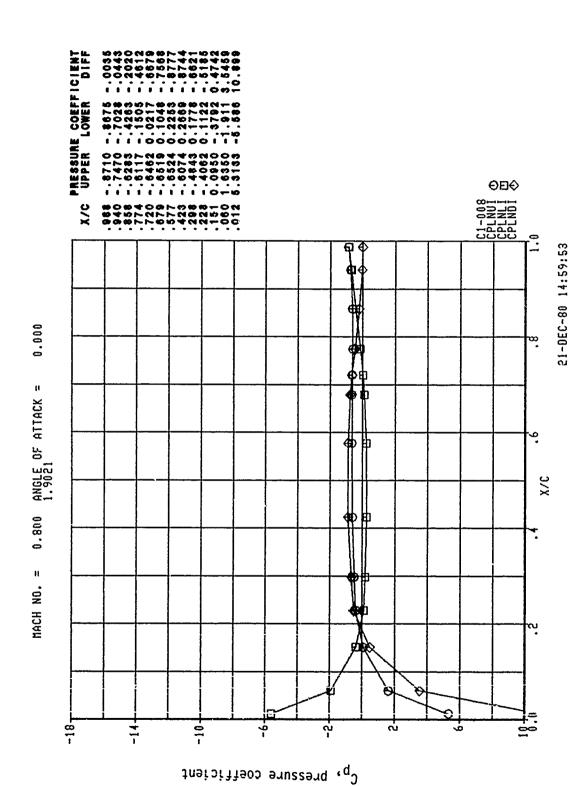
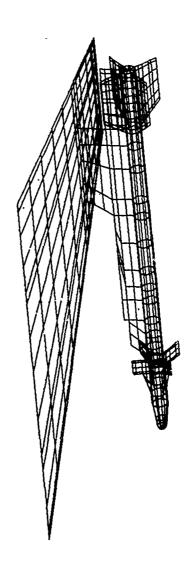


Figure 519, Chordwise Pressure Distribution, Imaginary Configuration



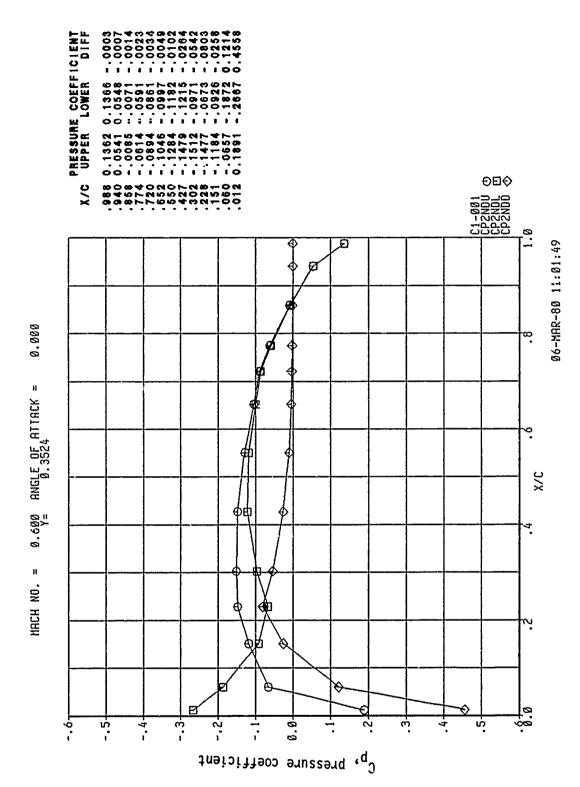


Figure 521, Chordwise Pressure Distribution, Steady, Configuration 7

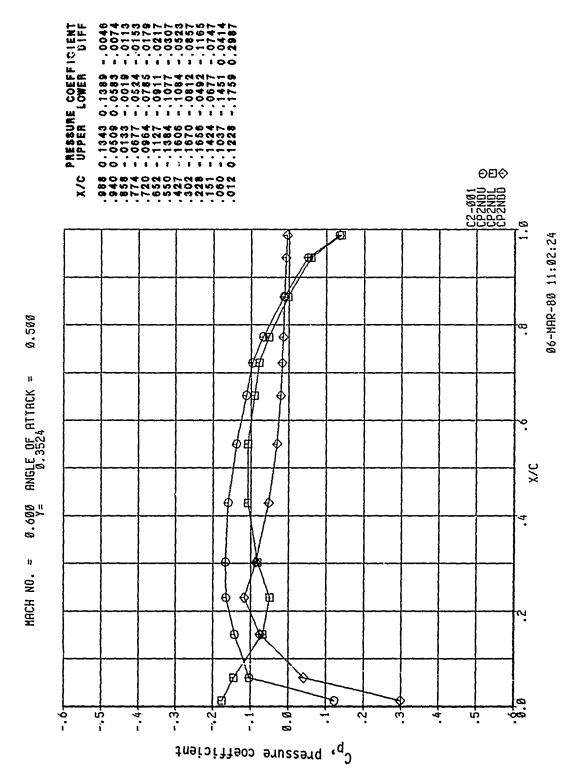


Figure 522, Chordwise Pressure Distribution, Steady, Configuration 7

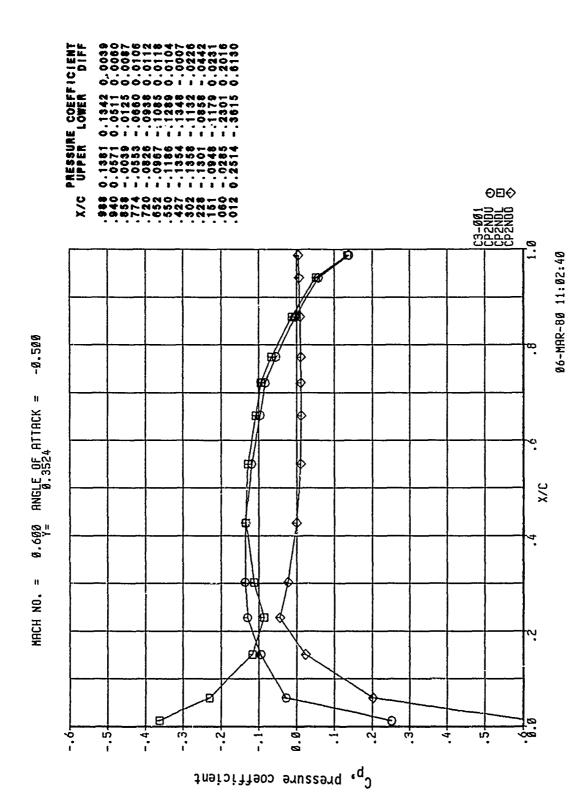


Figure 523, Chordwise Pressure Distribution, Steady, Configuration

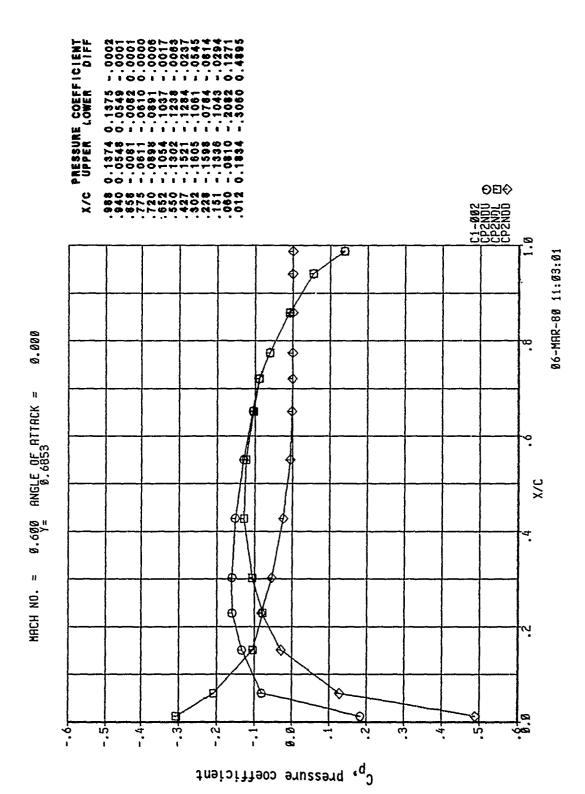


Figure 524, Chordwise Pressure Distribution, Steady, Configuration

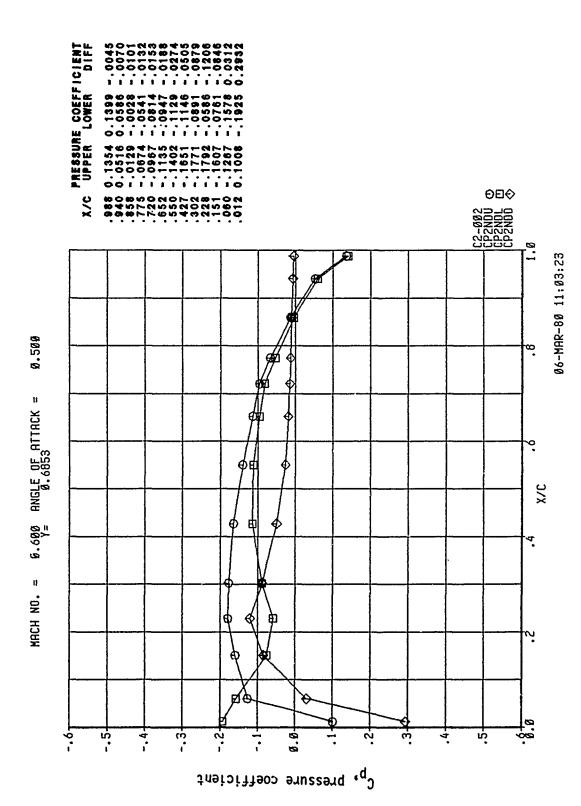


Figure 525, Chordwise Pressure Distribution, Steady, Configuration

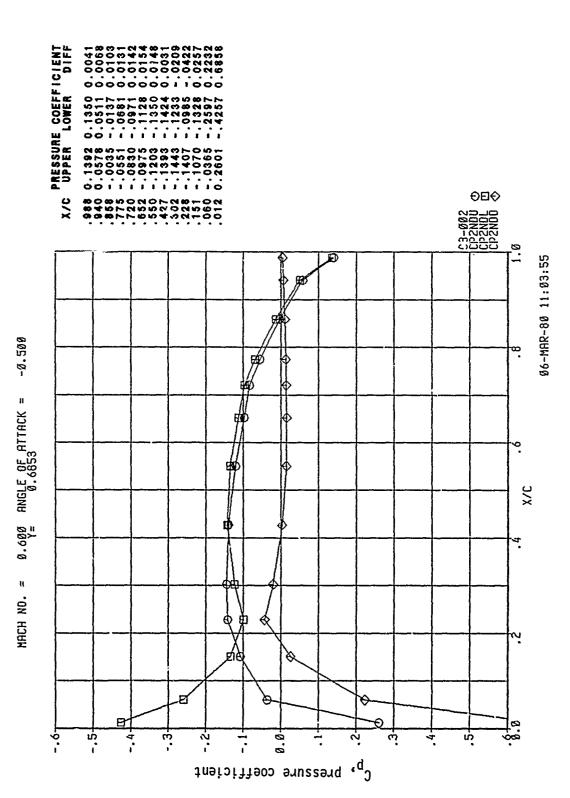
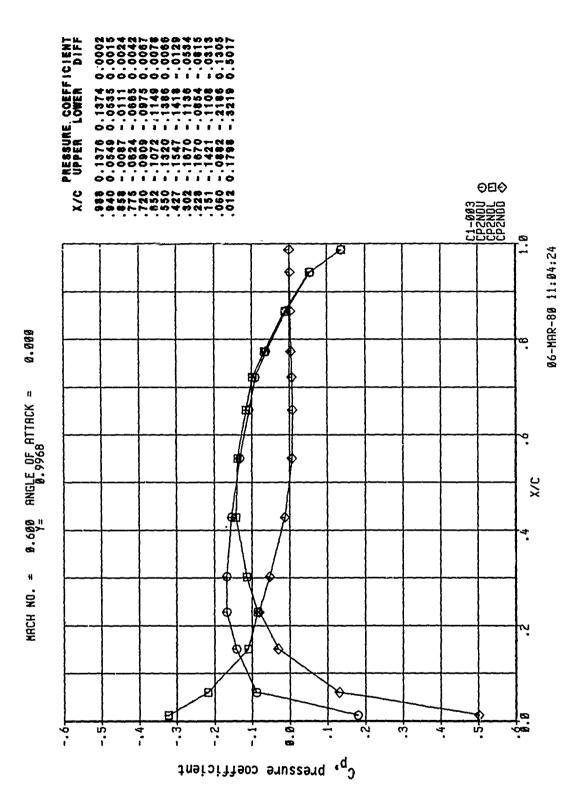


Figure 526, Chordwise Pressure Distribution, Steady, Configuration



527, Chordwise Pressure Distribution, Steady, Configuration Figure

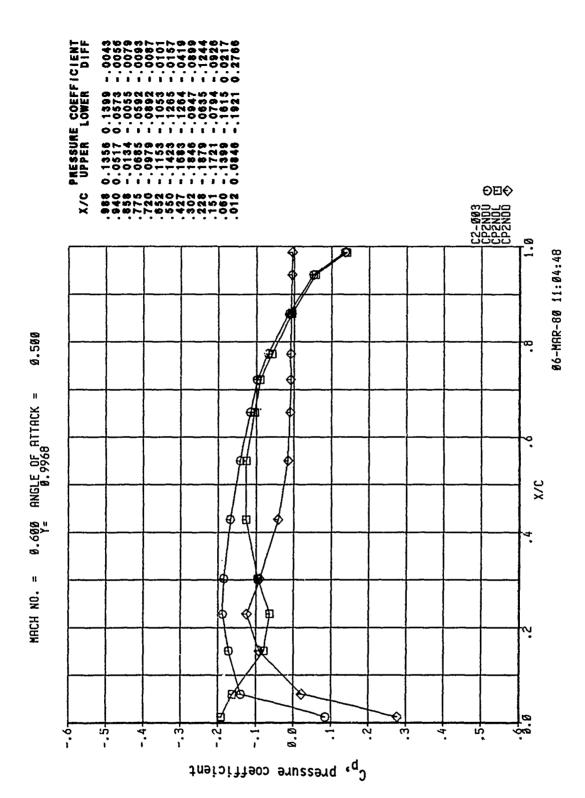


Figure 528, Chordwise Pressure Distribution, Steady, Configuration

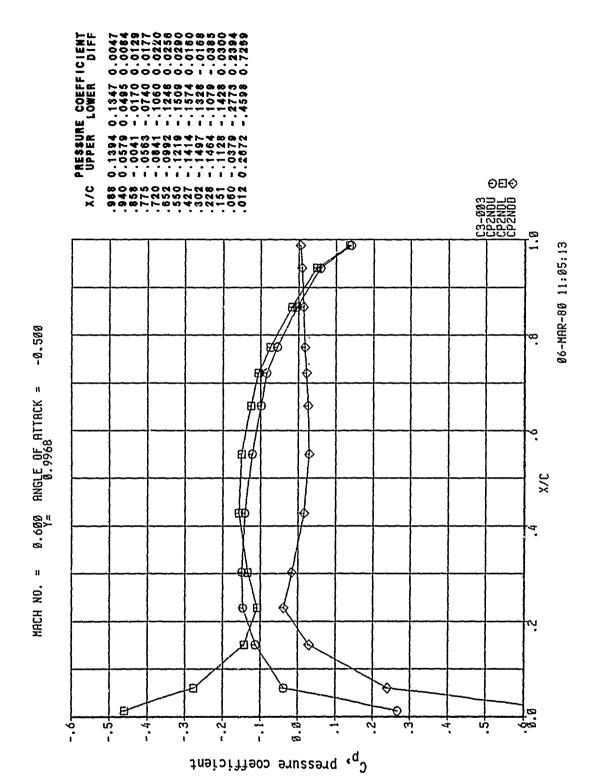
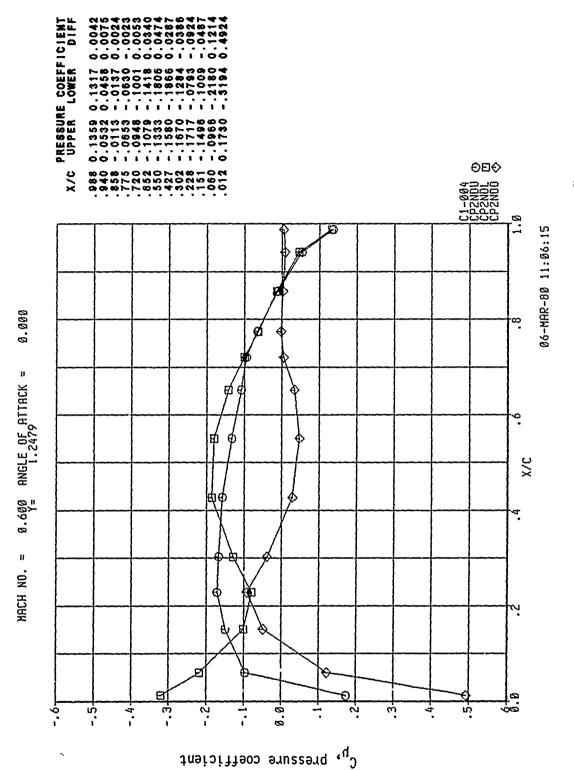


Figure 529, Chordwise Pressure Distribution, Steady, Configuration



gure 530, Chordwise Pressure Distribution, Steady, Configuration

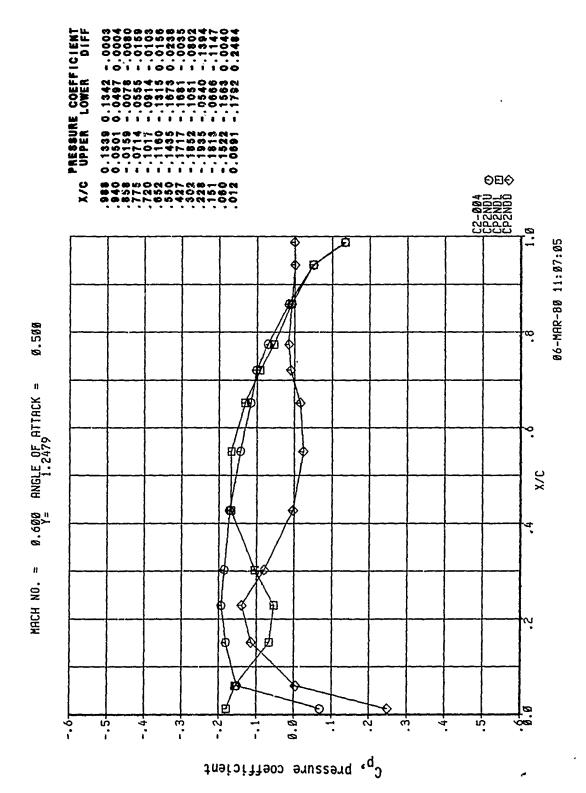


Figure 531, Chordwise Pressure Distribution, Steady, Configuration

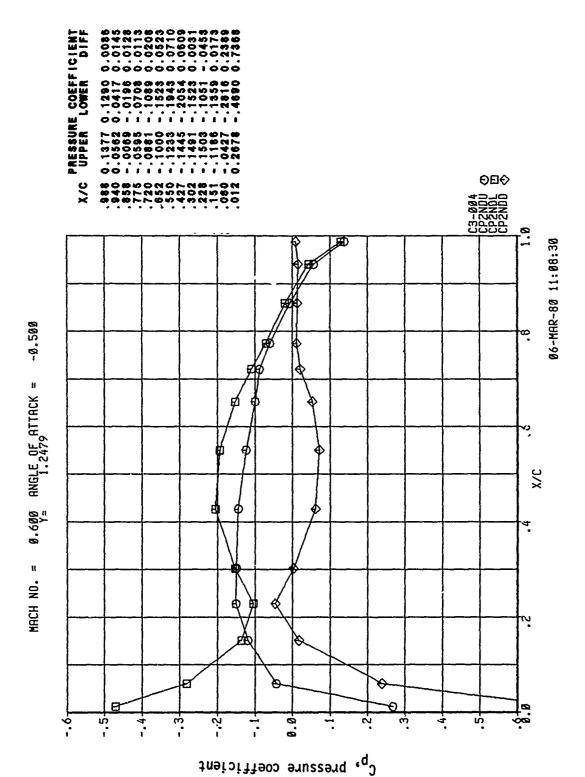
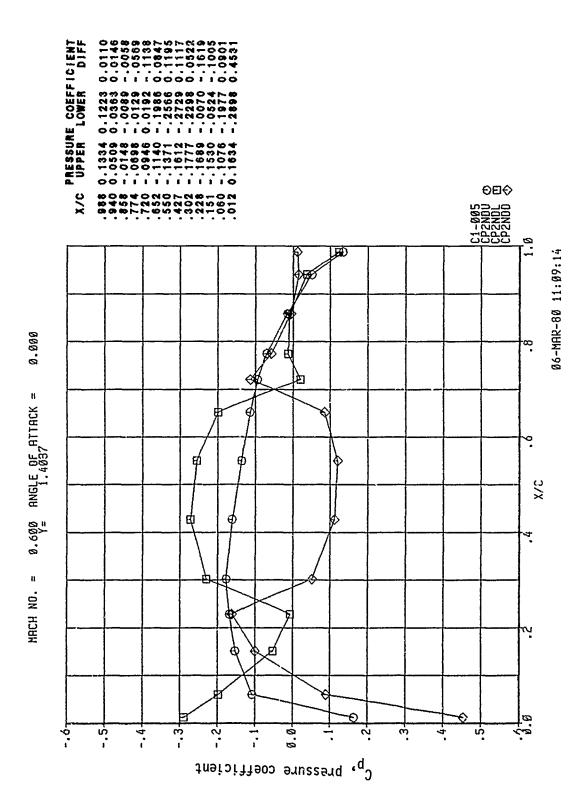


Figure 532, Chordwise Pressure Distribution, Steady, Configuration



gure 533, Chordwise Pressure Distribution, Steady, Configuration 7

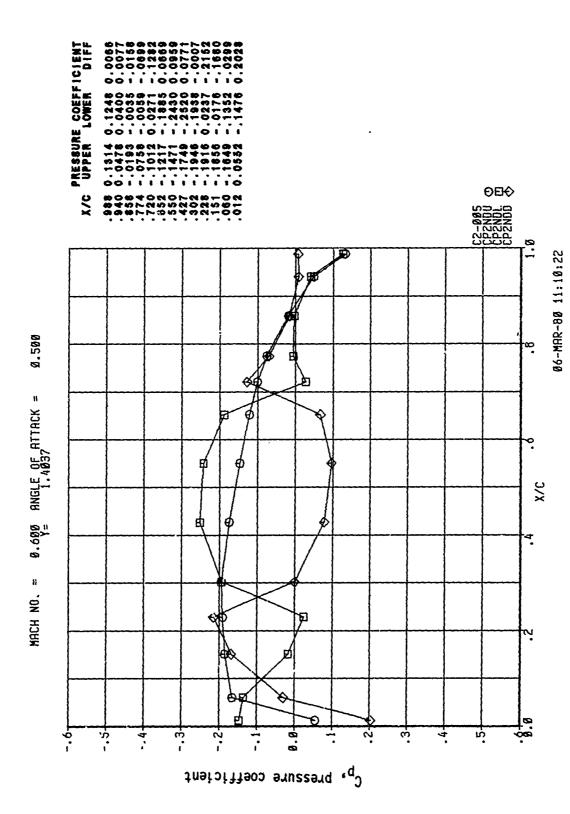


Figure 534, Chordwise Pressure Distribution, Steady, Configuration 7

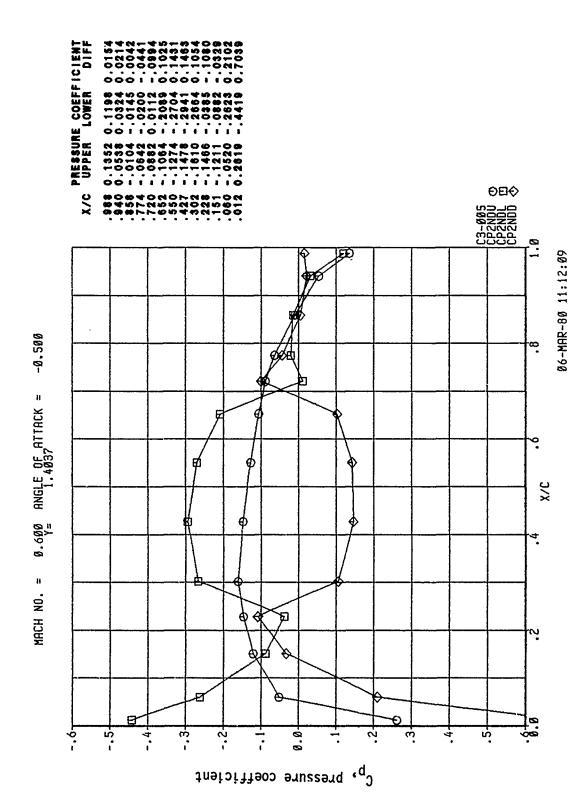


Figure 535, Chordwise Pressure Distribution, Steady, Configuration

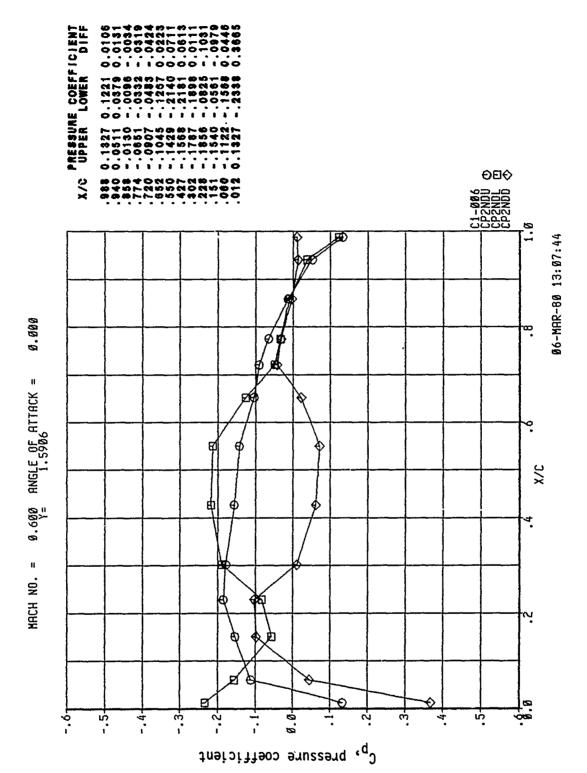


Figure 536, Chordwise Pressure Distribution, Steady, Configuration

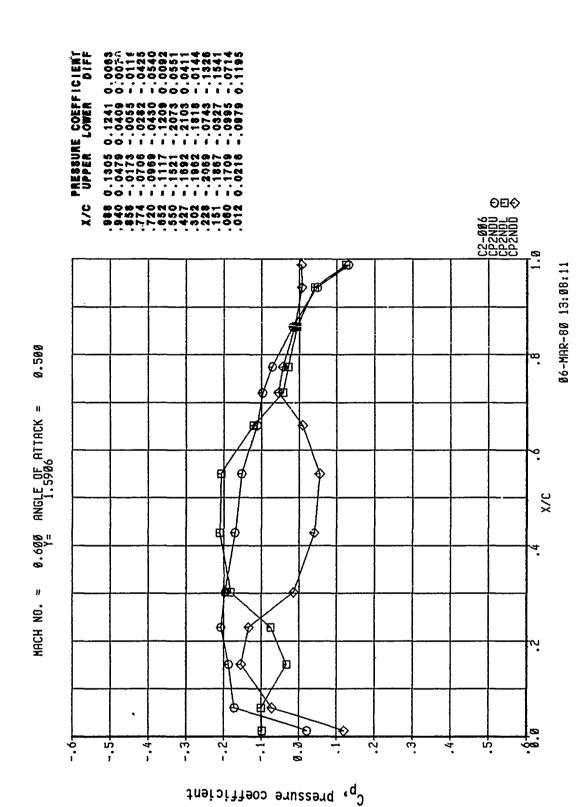


Figure 537, Chordwise Pressure Distribution, Steady, Configuration

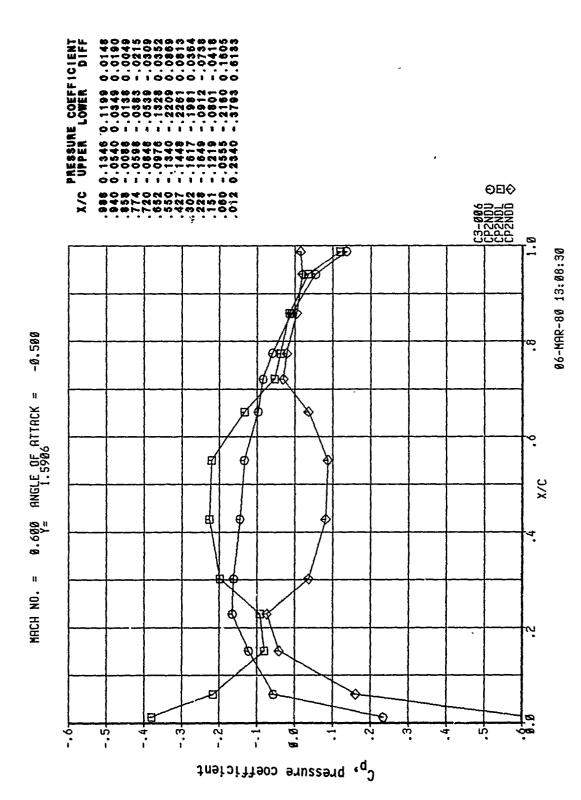
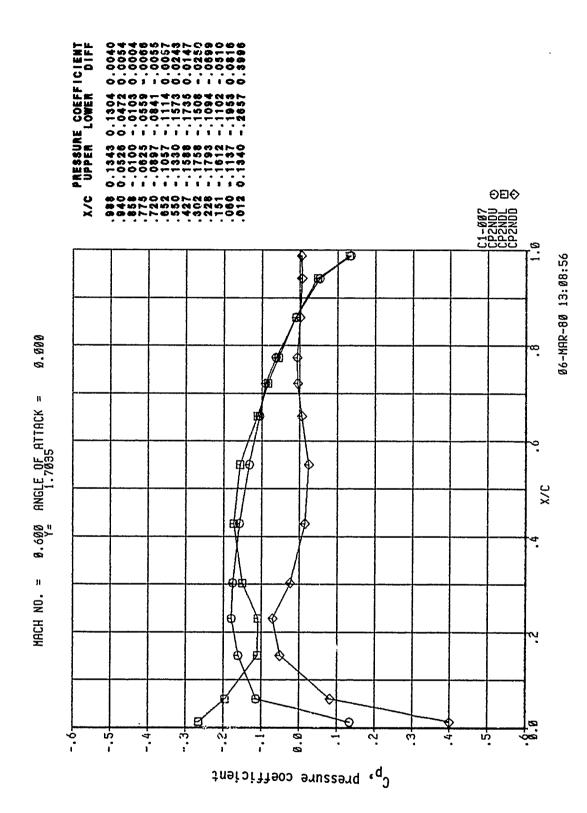
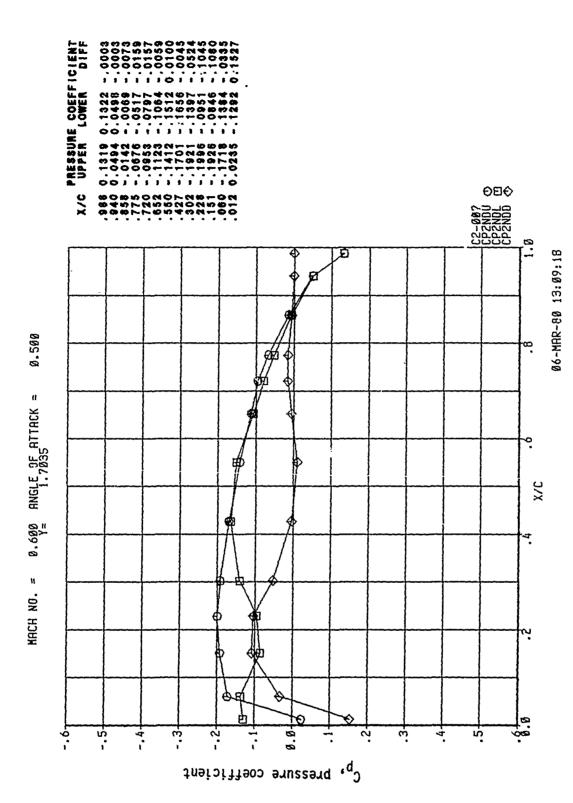


Figure 538, Chordwise Pressure Distribution, Steady, Configuration

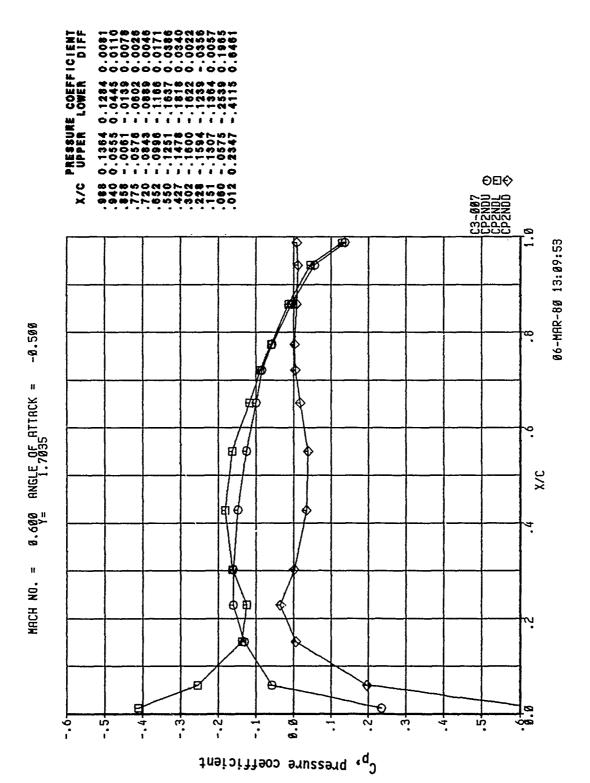


Chordwise Pressure Distribution, Steady, Configuration 539, Figure



; ;

Figure 540, Chordwise Pressure Distribution, Steady, Configuration 7



541, Chordwise Pressure Distribution, Steady, Configuration Figure

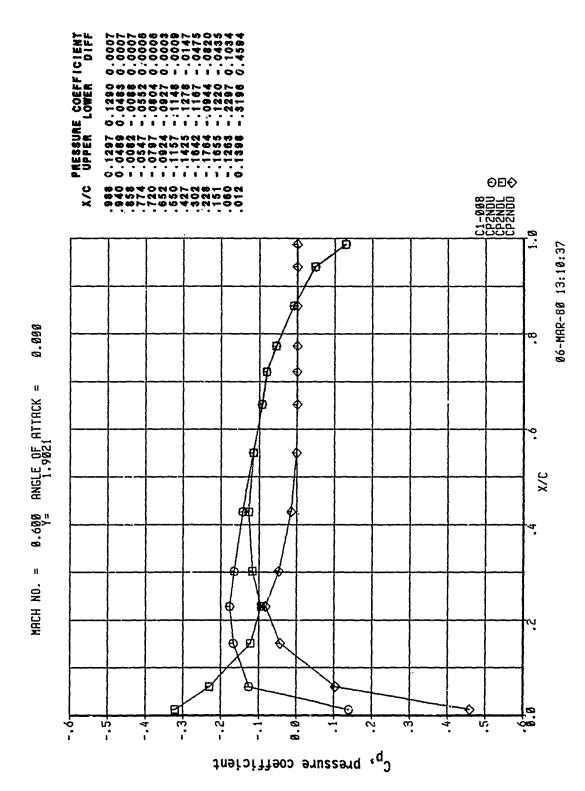


Figure 542, Chordwise Pressure Distribution, Steady, Configuration 7

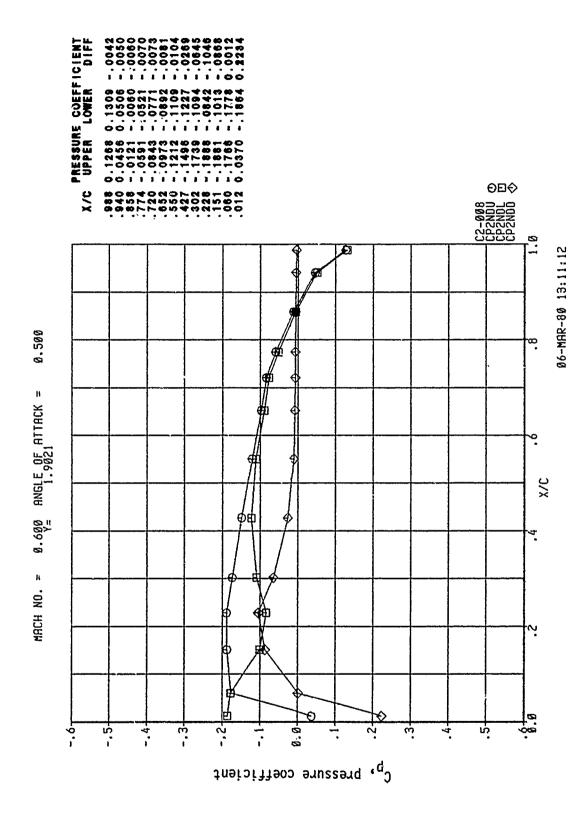


Figure 543, Chordwise Pressure Distribution, Steady, Configuration

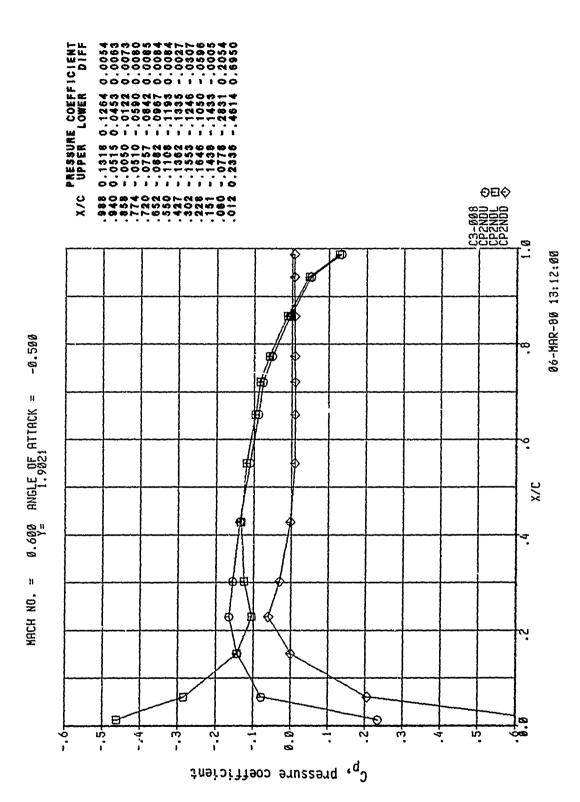
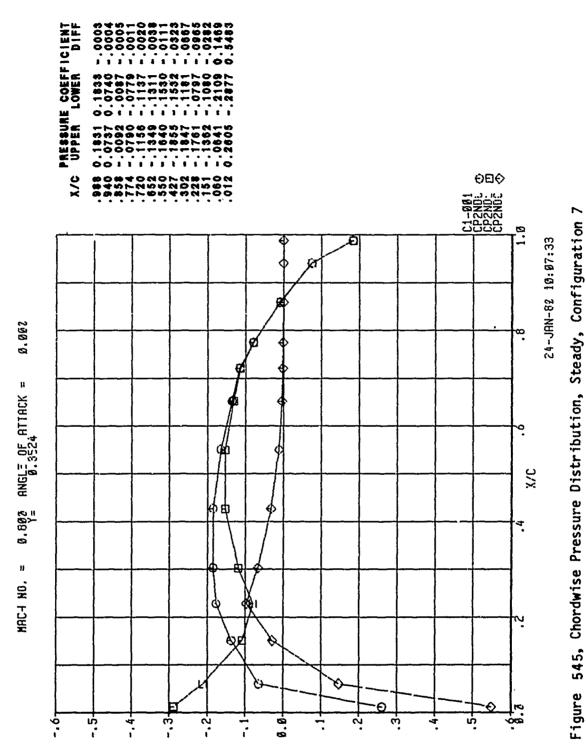


Figure 544, Chordwise Pressure Distribution, Steady, Configuration 7



C_p, pressure coefficient

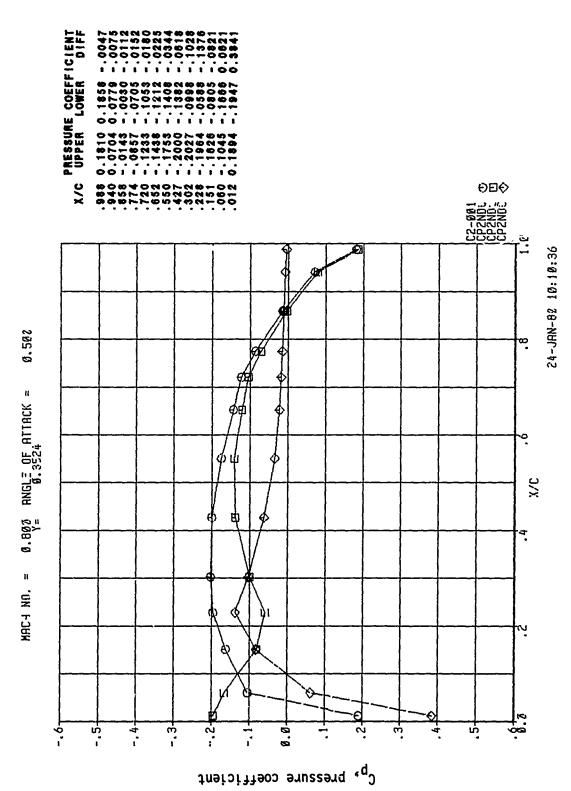


Figure 546, Chordwise Pressure Distribution, Steady, Configuration 7

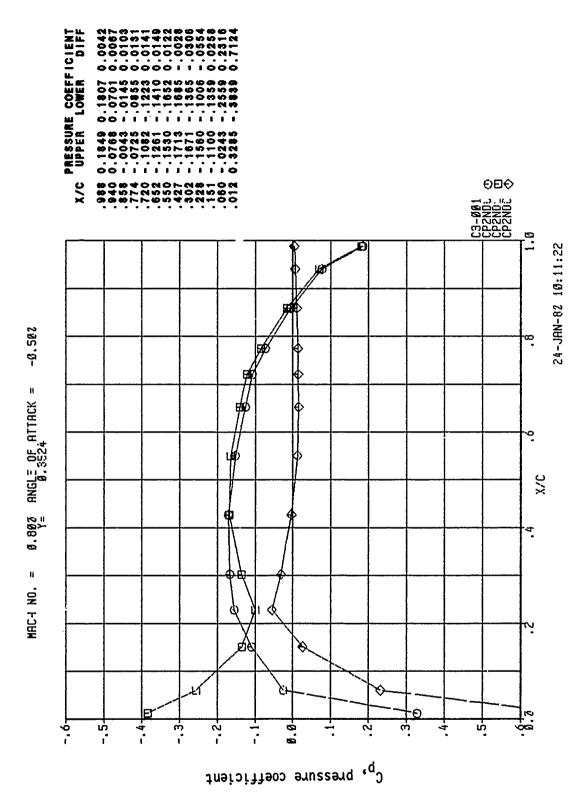


Figure 547, Chordwise Pressure Distribution, Steady, Configuration 7

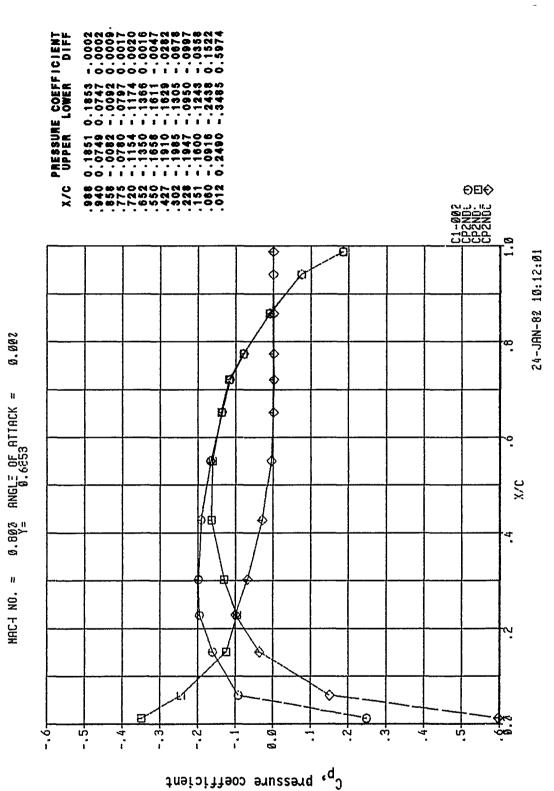


Figure 548, Chordwise Pressure Distribution, Steady, Configuration 7

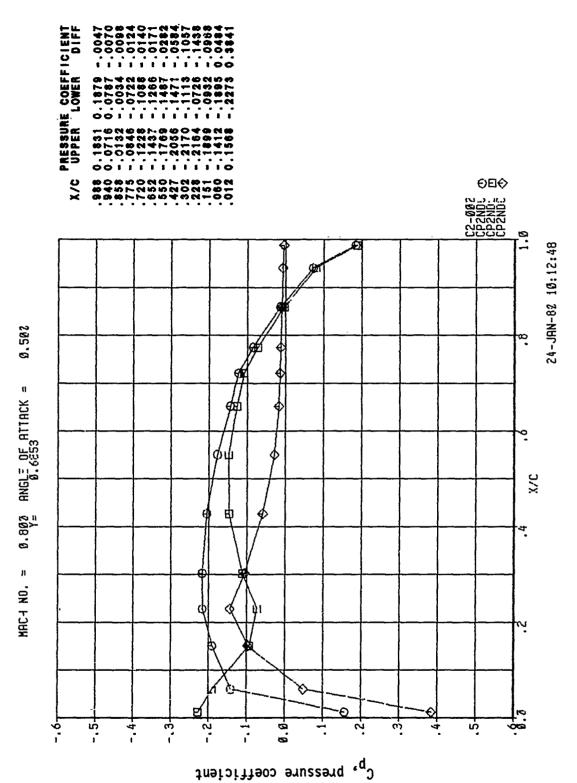
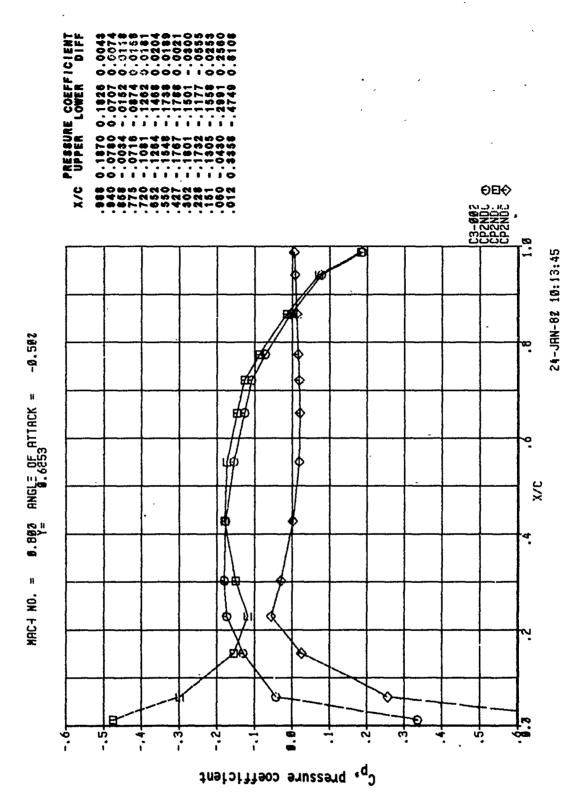


Figure 549, Chordwise Pressure Distribution, Steady, Configuration 7



550, Chordwise Pressure Distribution, Steady, Configuration Figure

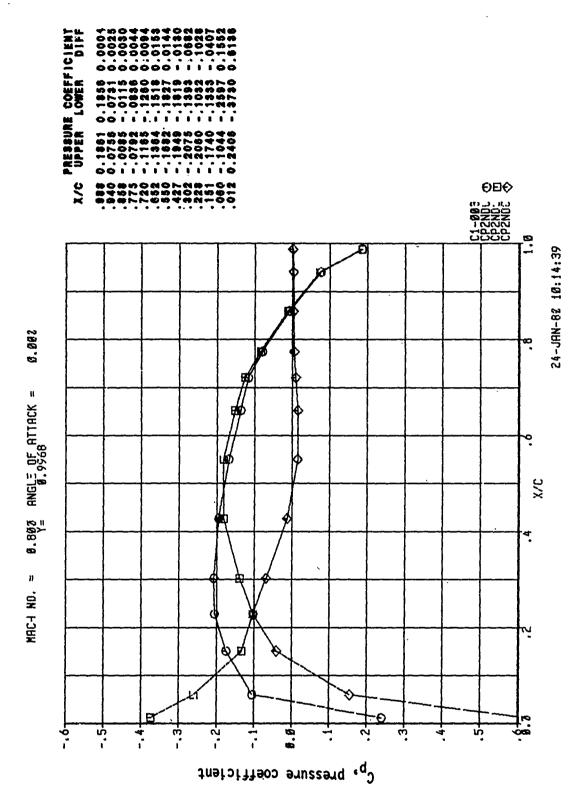


Figure 551, Chordwise Pressure Distribution, Steady, Configuration 7

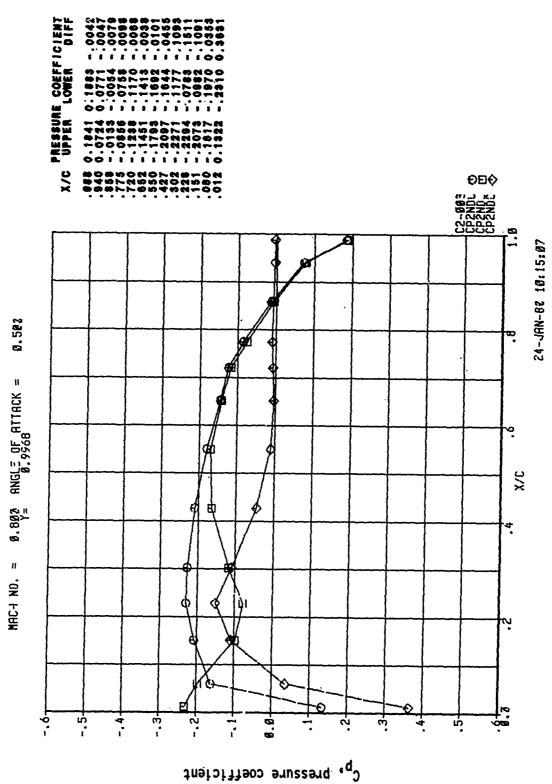


Figure 552, Chordwise Pressure Distribution, Steady, Configuration 7

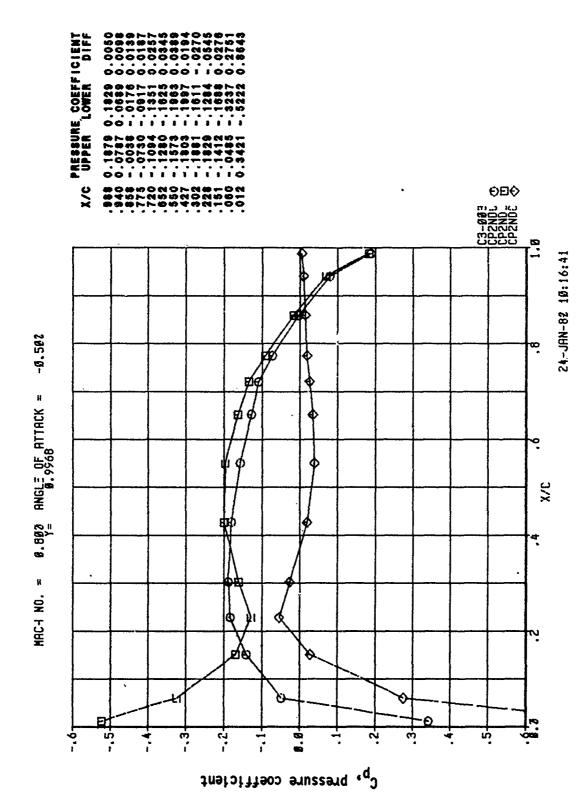


Figure 553, Chordwise Pressure Distribution, Steady, Configuration 7

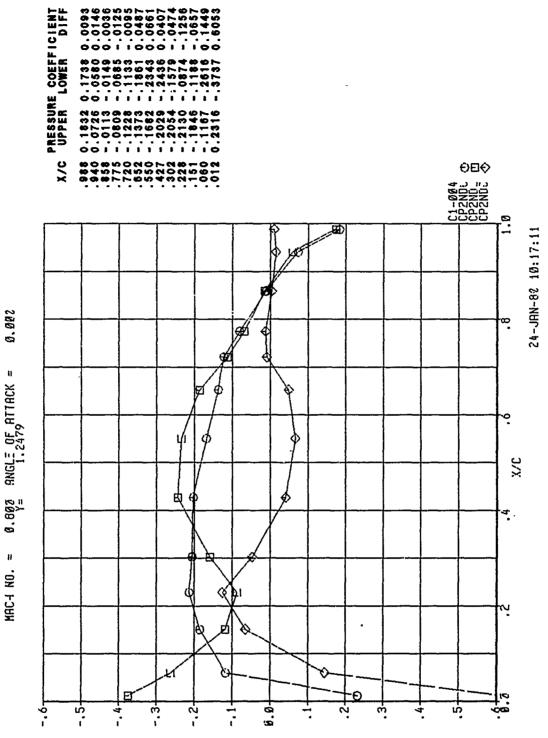


Figure 554, Chordwise Pressure Distribution, Steady, Configuration

 C_{p} , pressure coefficient

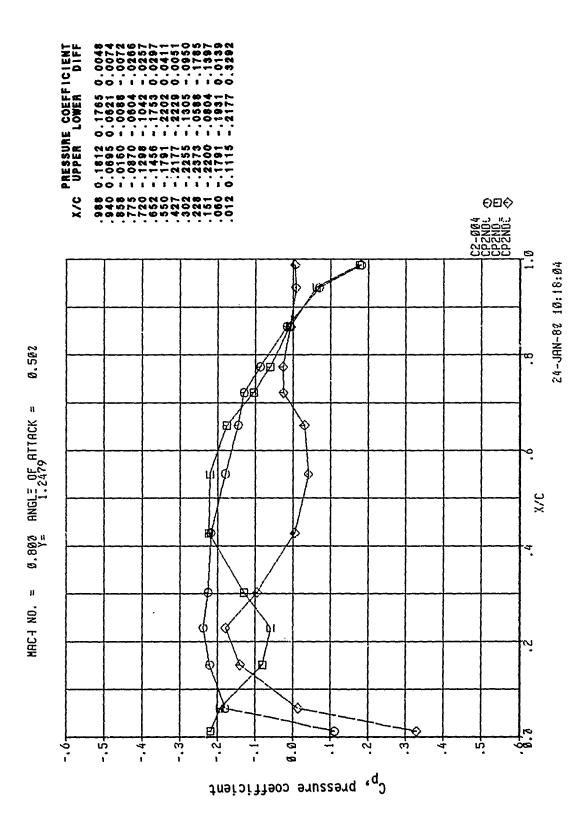


Figure 555, Chordwise Pressure Distribution, Steady, Configuration 7

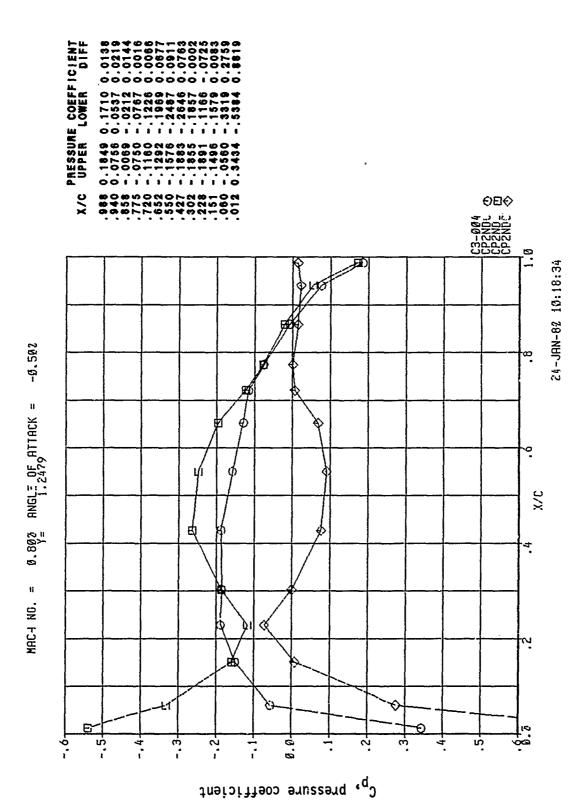
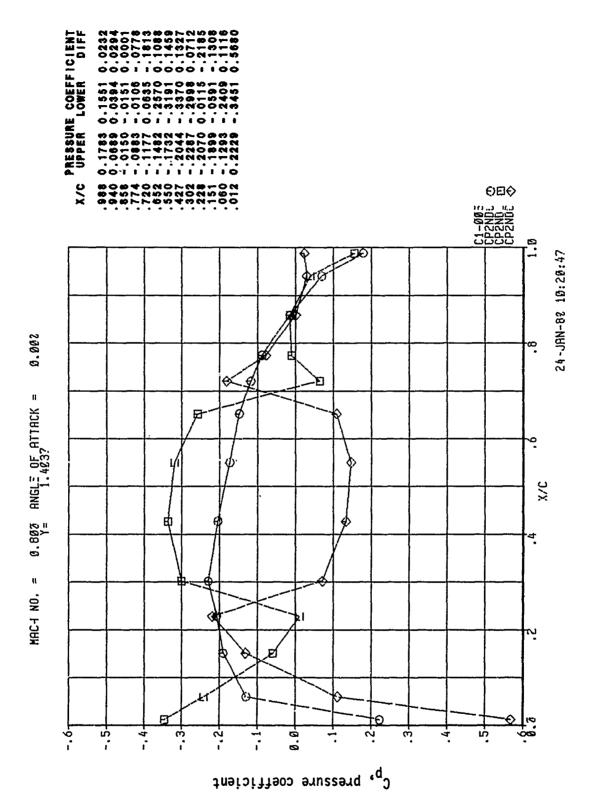


Figure 556, Chordwise Pressure Distribution, Steady, Configuration 7



557, Chordwise Pressure Distribution, Steady, Configuration Figure

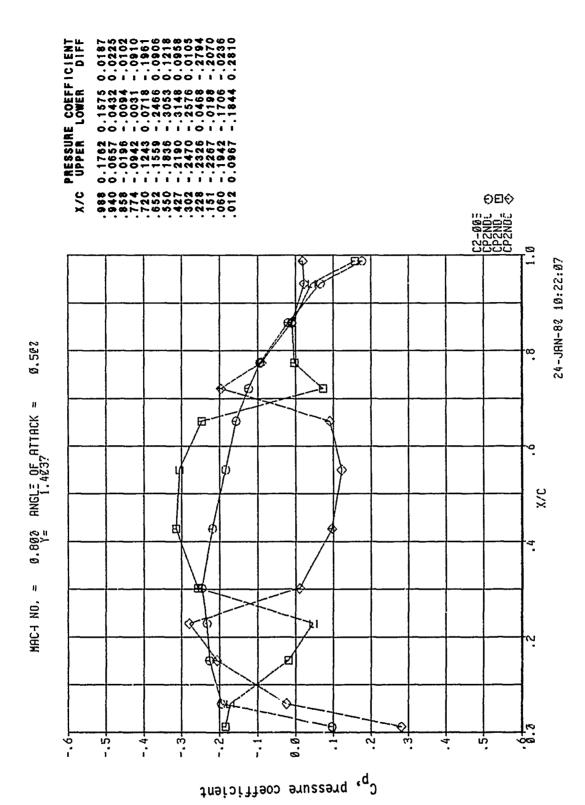
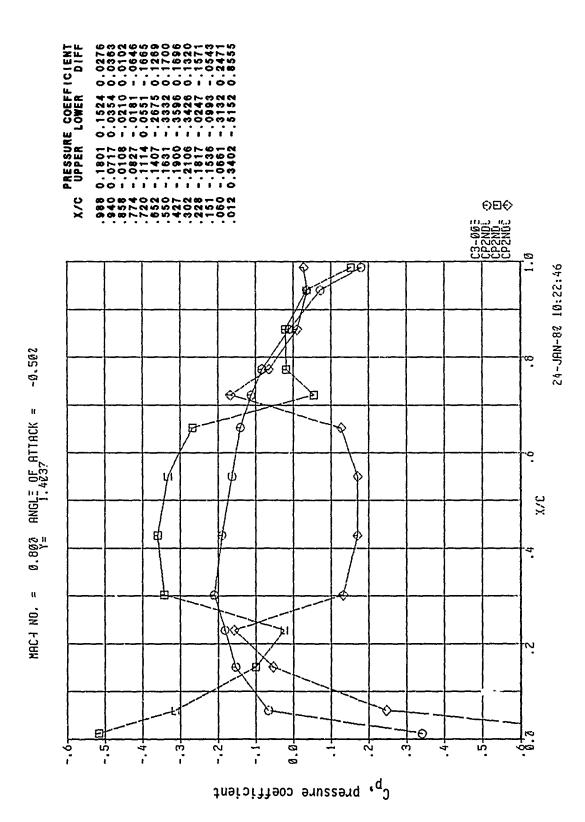


Figure 558, Chordwise Pressure Distribution, Steady, Configuration 7



gure 559, Chordwise Pressure Distribution, Steady, Configuration 7

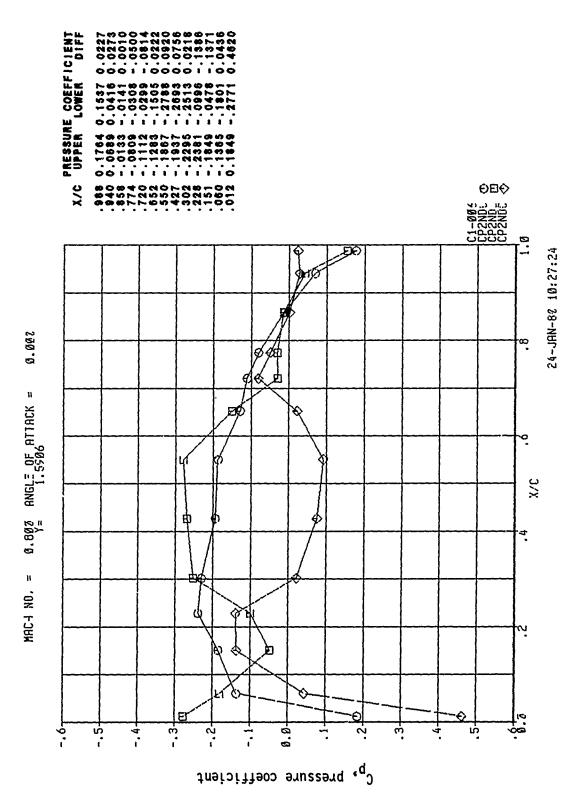


Figure 560, Chordwise Pressure Distribution, Steady, Configuration 7

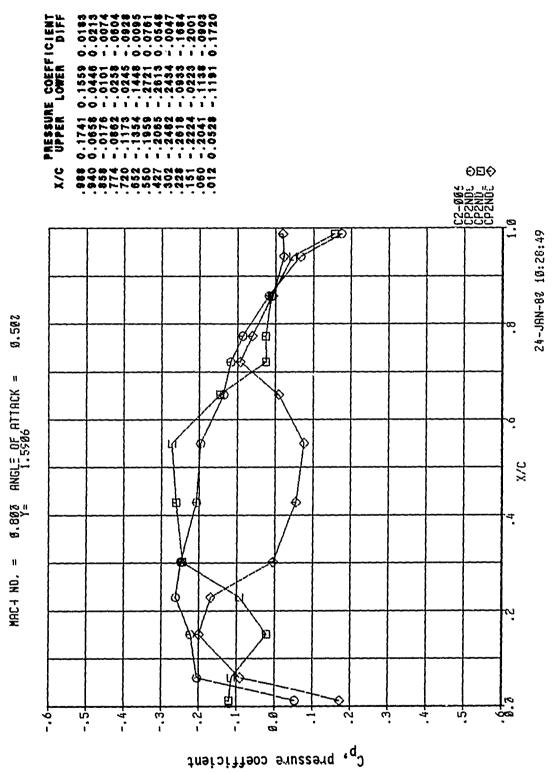


Figure 561, Chordwise Pressure Distribution, Steady, Configuration 7

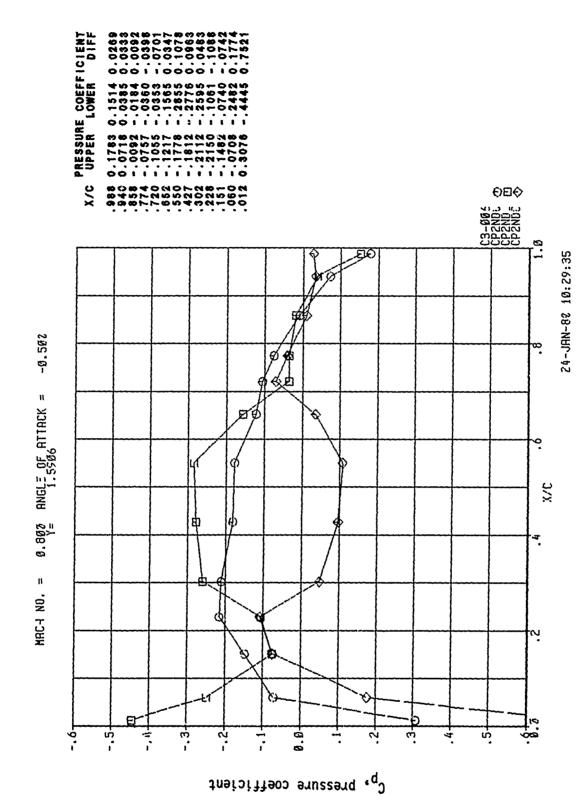


Figure 562, Chordwise Pressure Distribution, Steady, Configuration 7

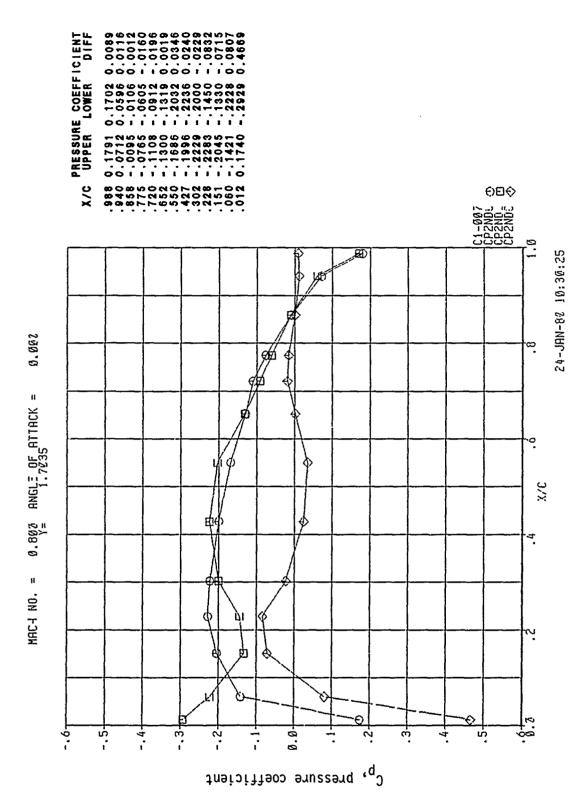
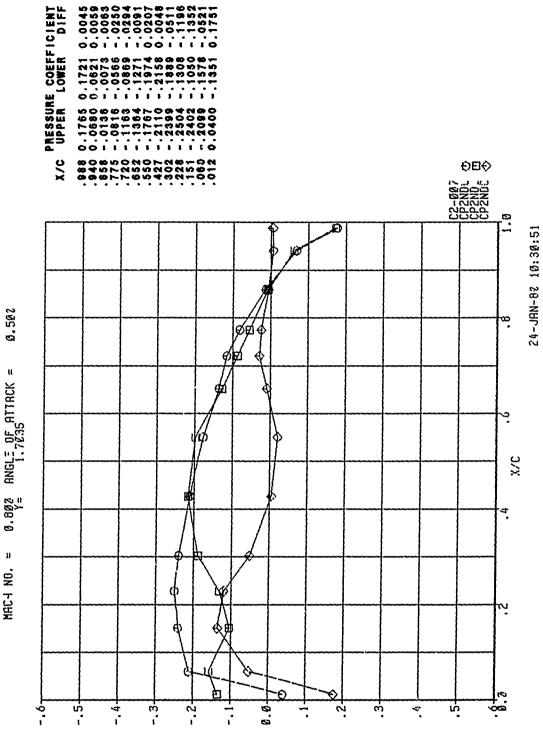


Figure 563, Chordwise Pressure Distribution, Steady, Configuration 7



295.0

11

MACH NO.

Figure 564, Chordwise Pressure Distribution, Steady, Configuration

 C_{p} , pressure coefficient

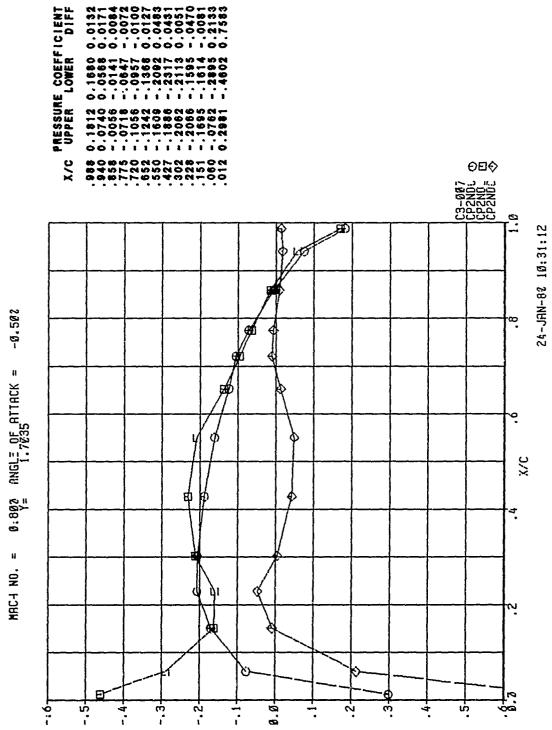
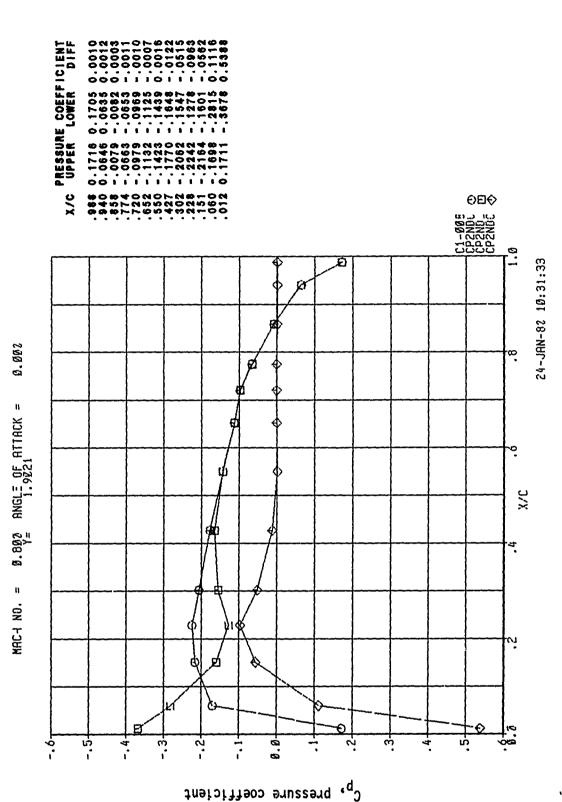


Figure 565, Chordwise Pressure Distribution, Steady, Configuration 7

 $c_{
m p}$, pressure coefficient



ŢŢ

Figure 566, Chordwise Pressure Distribution, Steady, Configuration 7

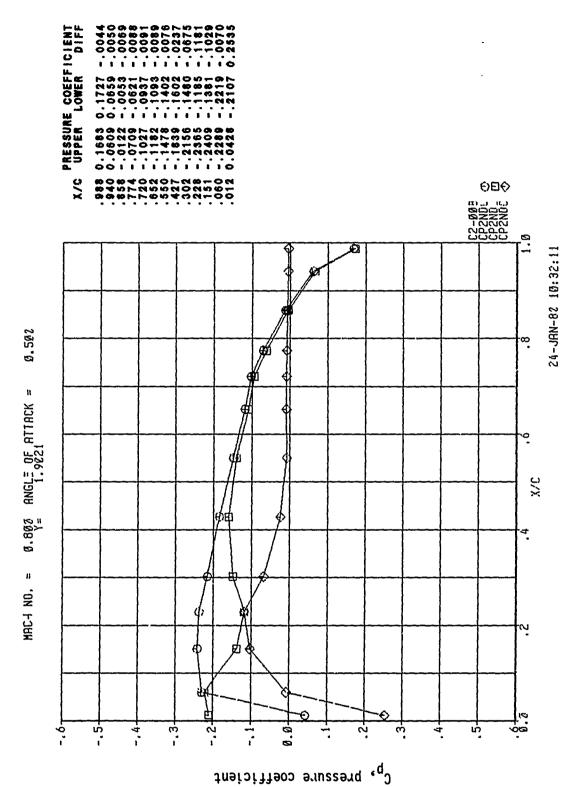


Figure 567, Chordwise Pressure Distribution, Steady, Configuration 7

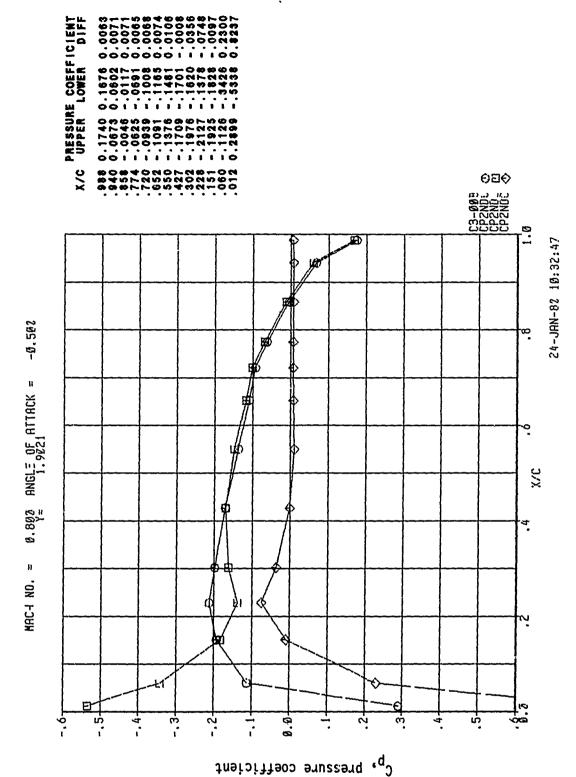
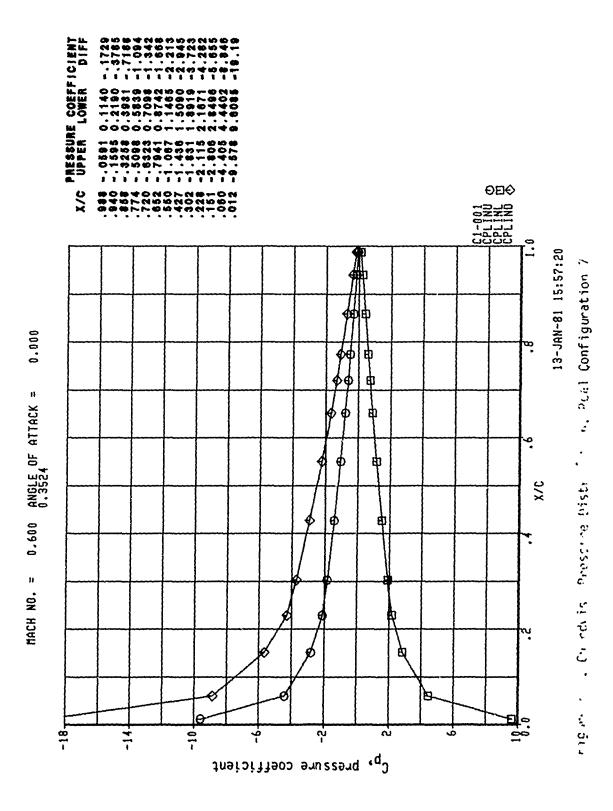


Figure 568, Chordwise Pressure Distribution, Steady, Configuration 7



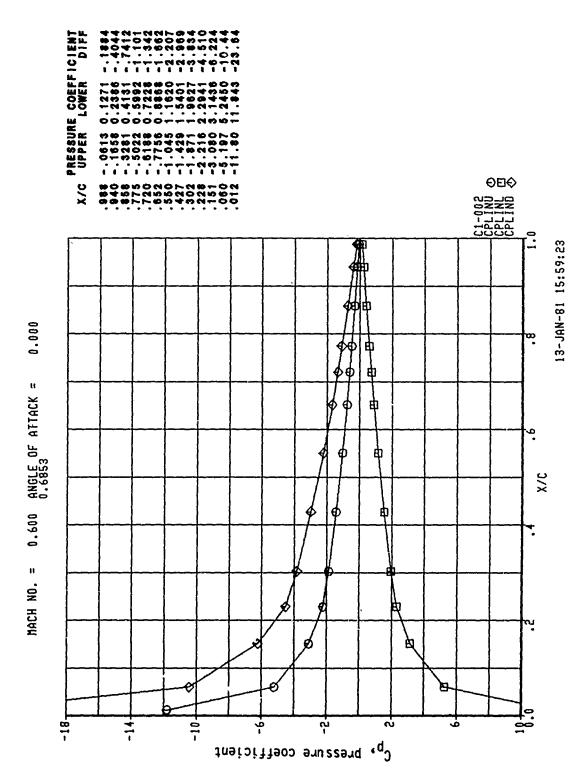


Figure 570, Chordwise Pressure Distribution, Real Configuration 7

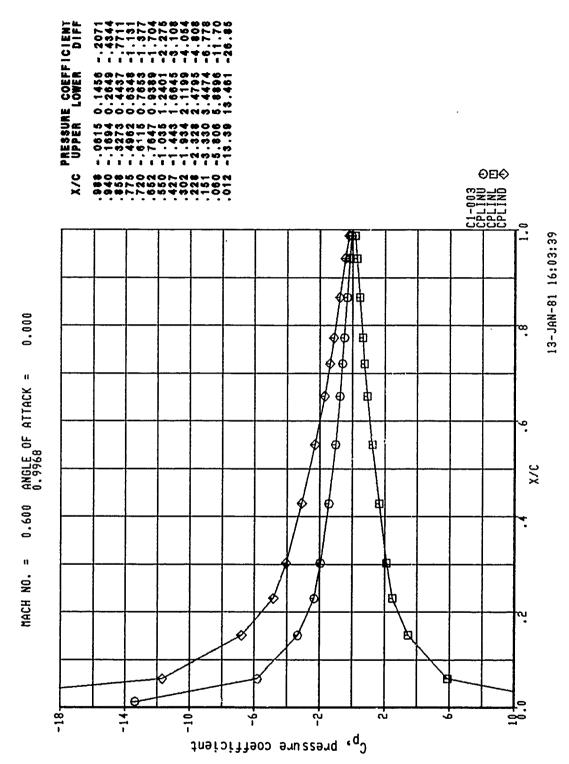


Figure 571, Chordwise Pressure Distribution, Real Configuration 7

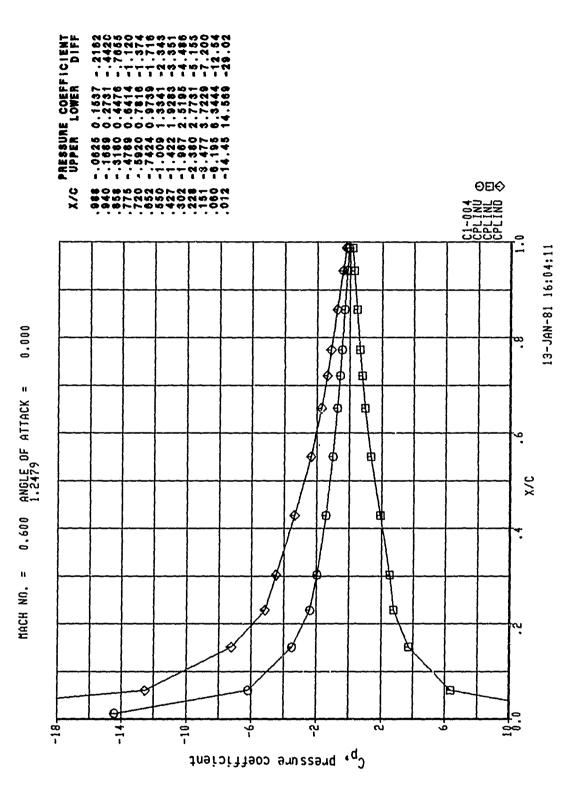


Figure 572, Chordwise Pressure Distribution, Real Configuration 7

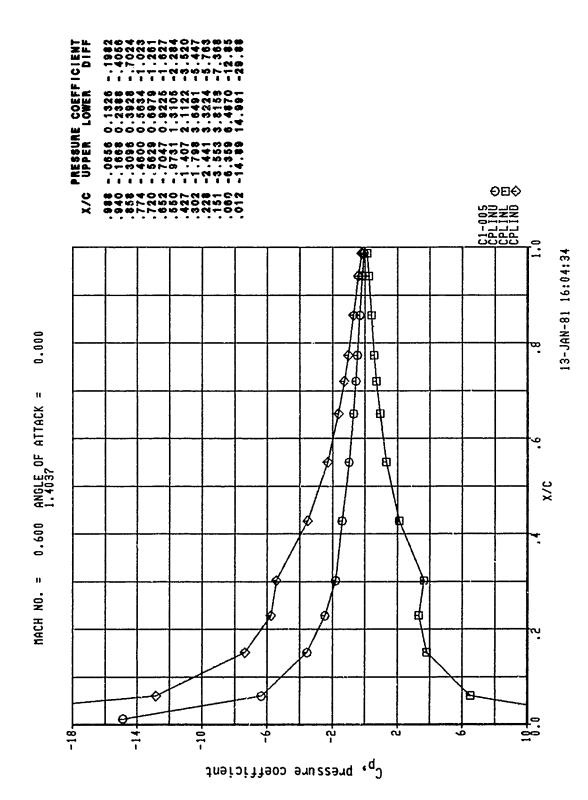


Figure 573, Chordwise Pressure Distribution, Real Configuration 7

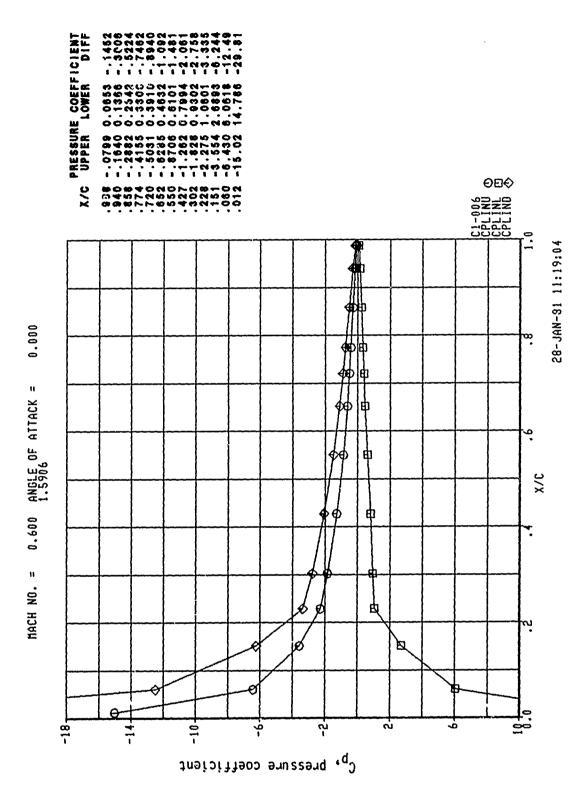


Figure 574, Chordwise Pressure Distribution, Real Configurat 院 ,

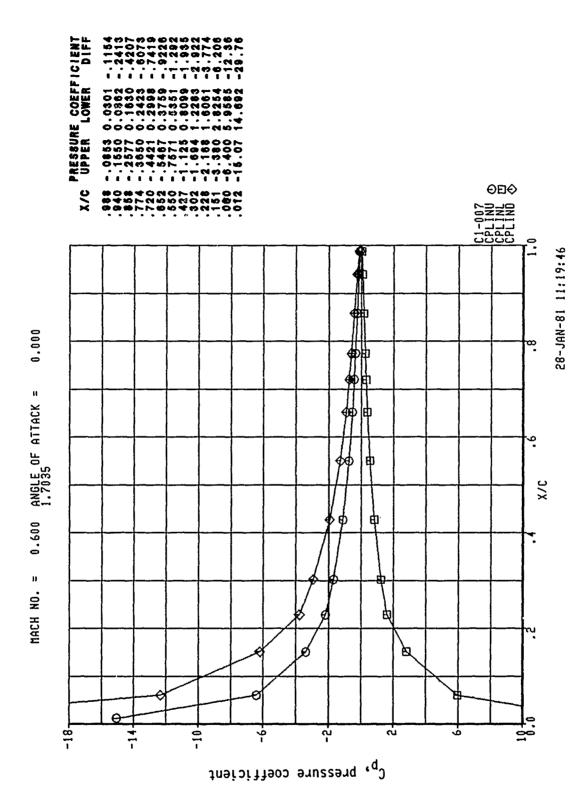


Figure 575, Chordwise Pressure Distribution, Real Configuration ;

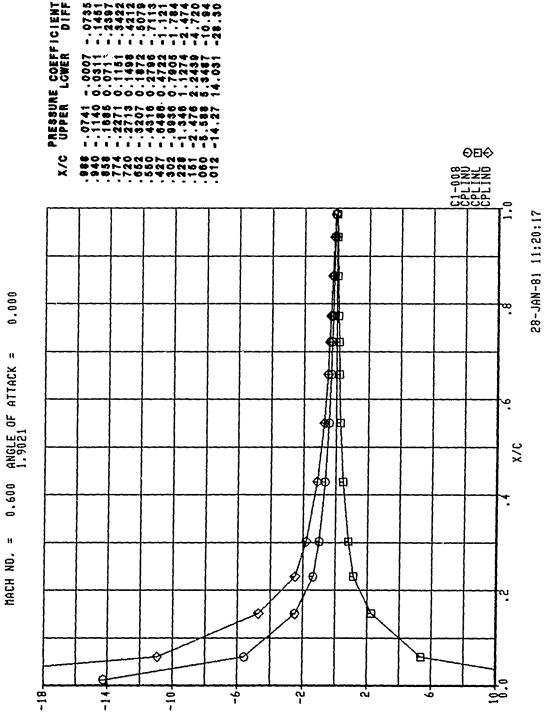


Figure 576, Chordwise Pressure Distribution, Real Configuration 7

figure coefficient q_0

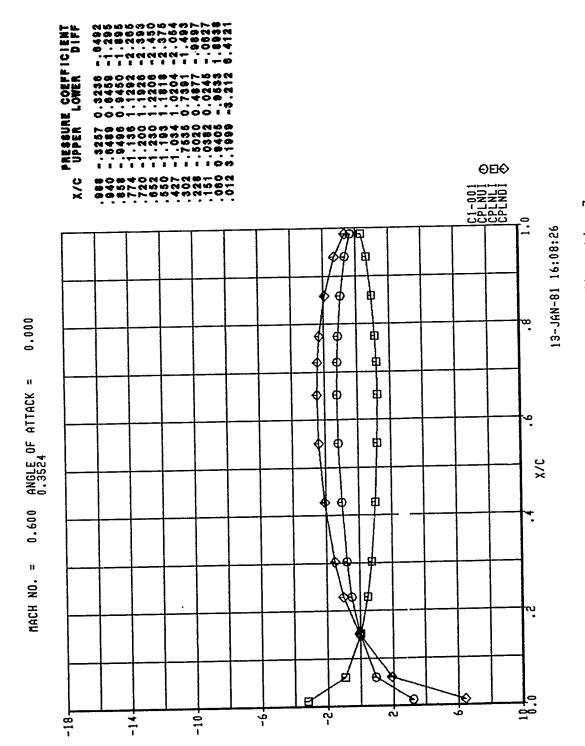


Figure 577, Chordwise Pressure Distribution, Imaginary Configuration 7

 $C_{\mathbf{p}}$, pressure coefficient

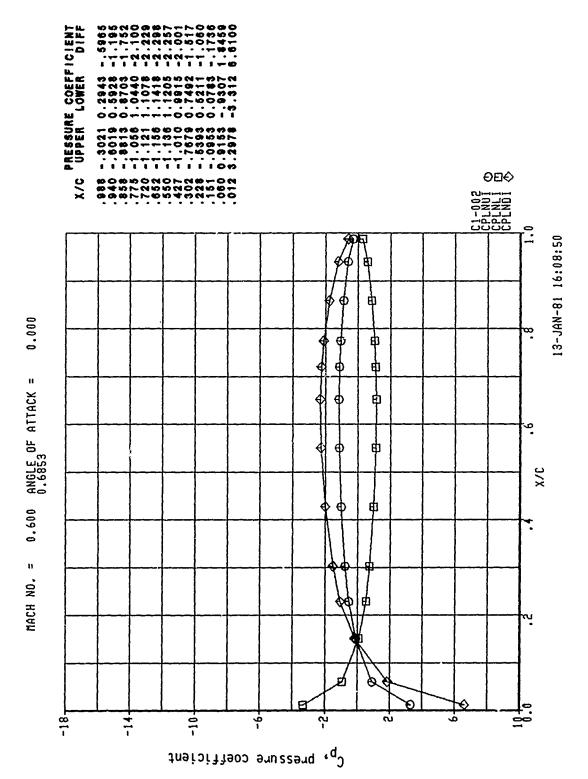


Figure 578, Chordwise Pressure Distribution, Imaginary Configuration

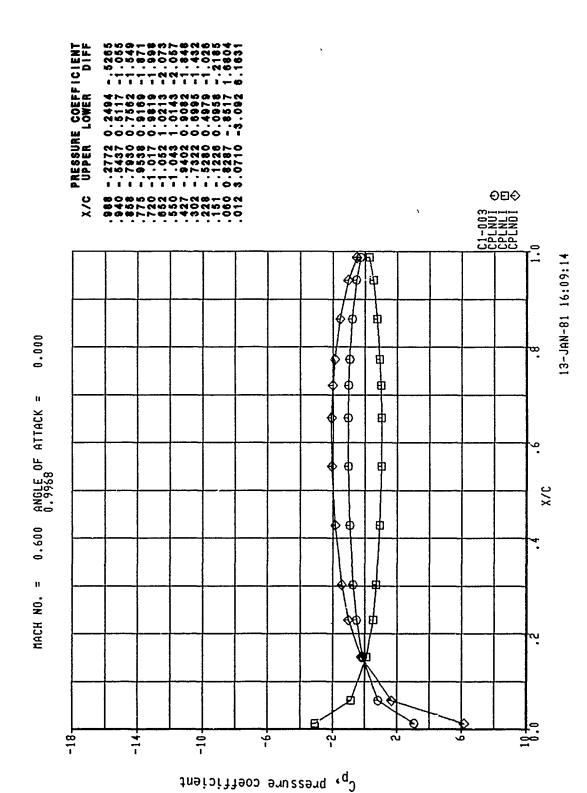


Figure 579, Chordwise Pressure Distribution, Imaginary Configuration 7

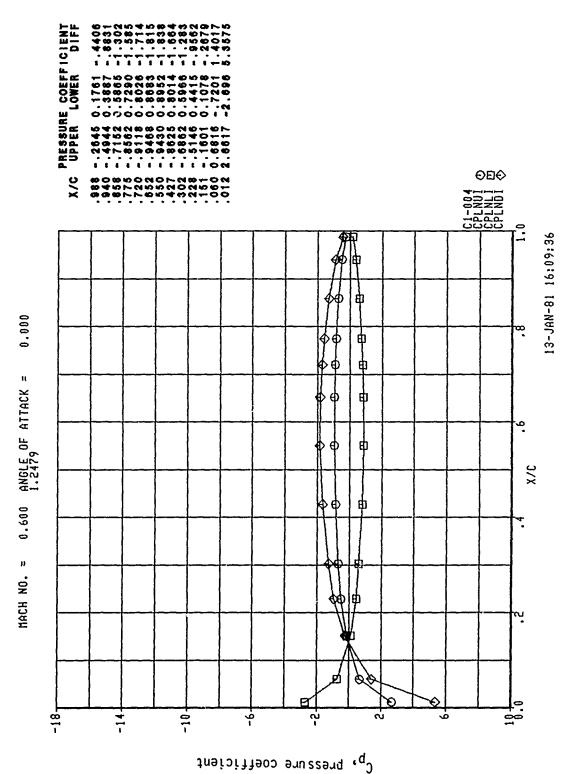


Figure 580, Chordwise Pressure Distribution, Imaginary Configuration 7

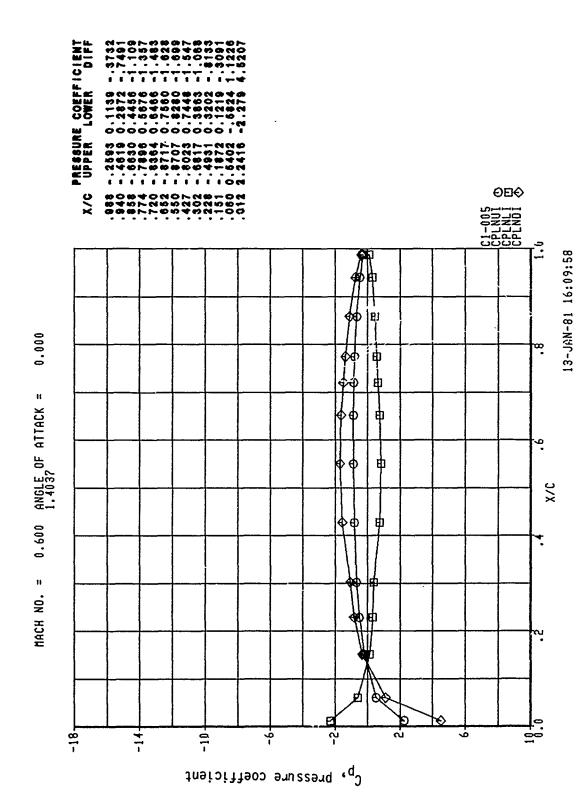


Figure 581, Chordwise Pressure Distribution, Imaginary Configuration

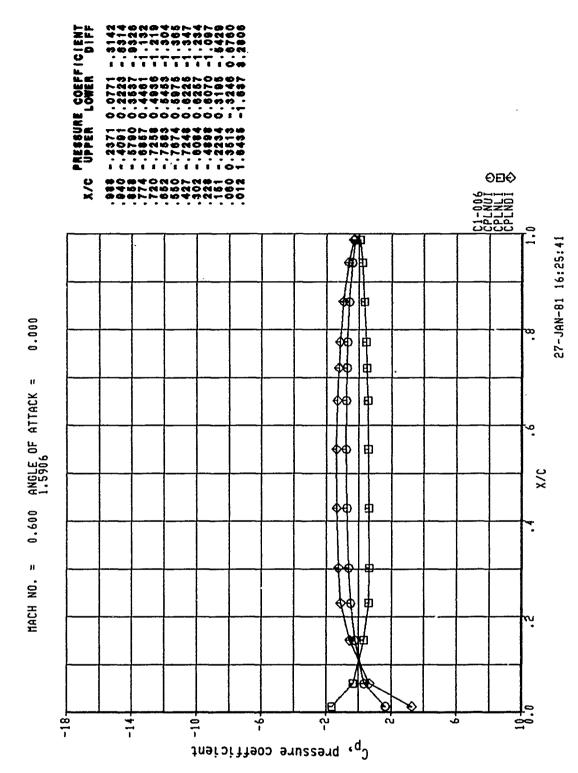


Figure 582, Chordwise Pressure Distribution, Imaginary Configuration 7

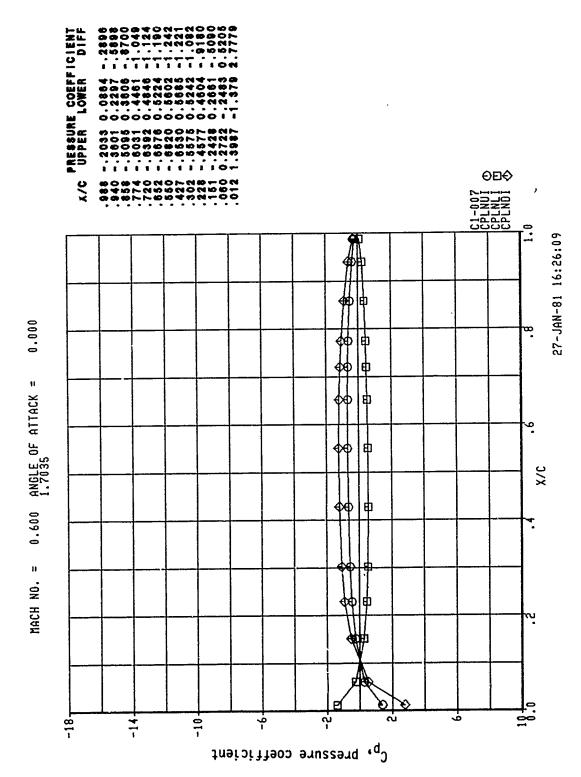


Figure 583, Chordwise Pressure Distribution, Imaginary Configuration

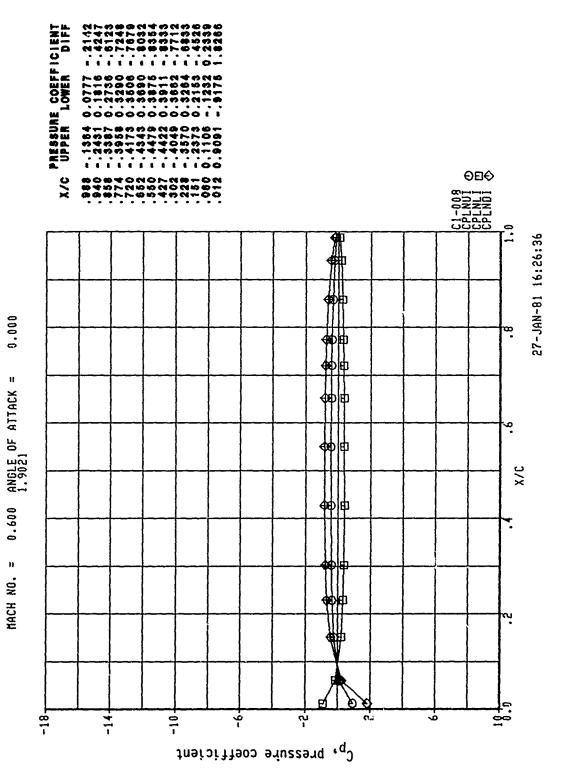


Figure 584, Chordwise Pressure Distribution, Imaginary Configuration 7